THE IMPACT OF FOREIGN STOCK MARKETS ON MACROECONOMIC DYNAMICS IN OPEN ECONOMIES: A STRUCTURAL ESTIMATION

FABIO MILANI

University of California, Irvine

Abstract. With the increased international financial integration in recent years, bilateral financial linkages between countries may have a growing influence on their real economies. This paper employs a structural two-country New Keynesian model, which incorporates a cross-border wealth channel, to estimate the effect that foreign stock market fluctuations may have on macroeconomic variables in open economy countries.

The model is estimated using Bayesian methods on a sample of open economies that can potentially be affected by changes in a larger foreign stock market: Australia, Canada, New Zealand, Ireland, Austria, and the Netherlands. The estimation allows for deviations from rational expectations and for learning by economic agents.

The empirical results indicate important cross-country wealth effects for Ireland and Austria, from fluctuations in the U.S. and U.K. and in the U.S. and German stock markets, respectively; the wealth effect is largest in Ireland. The data favor, instead, specifications with no significant wealth effect for the remaining countries. Foreign stock price fluctuations, however, still play a role by affecting domestic expectations about future output gaps in all countries in the sample.

Keywords: Stock Market, Wealth Effect, International Portfolio Holdings, Bayesian estimation, Adaptive Learning, Open Economy, Expectations.

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Address for correspondence: Department of Economics, 3151 Social Science Plaza, University of California, Irvine, CA 92697-5100. *Phone:* 949-824-4519. *Fax:* 949-824-2182. *E-mail:* fmilani@uci.edu. *Homepage:* http://www.socsci.uci.edu/˜fmilani.

1. Introduction

The past two decades have been characterized by a substantial increase in international financial integration. Lane and Milesi-Ferretti (2001, 2003, 2008) extensively document the rapid growth over the past years in the external wealth held by most countries: they show, for example, that the stock of external assets and liabilities as a fraction of GDP has risen by a factor of seven over the 1970-2004 period in industrial countries. During the same period, the share of equities in their external wealth has also increased and the home bias in equity holdings has become less severe for several countries (e.g., Sorensen et al., 2007, Baele et a., 2007).

As a consequence, bilateral financial linkages between countries may matter more than they did in the past. Those economies in which a large fraction of wealth is invested in foreign equities, for example, may be affected by fluctuations in stock prices in a foreign financial market. A cross-border wealth effect from changes in international stock prices may hence have an important impact on open economies' aggregate consumption and real activity.

Several studies have analyzed the wealth channel in a closed economy framework, from early work by Ando and Modigliani (1963) to more recent contributions.[1] The majority of studies focus on the U.S., but similar regressions have been estimated for a variety of countries.[2]

The potential effects of fluctuations in international asset prices on domestic economies, instead, have not been widely researched yet. This paper tries to fill this gap by estimating the magnitude of the international wealth effect for a set of open economies.

It does so by estimating a structural model, which follows Di Giorgio and Nistico' (2007), for a two-country open economy, extended to incorporate an international wealth channel. The magnitude of the wealth channel depends on the length of the planning horizon agents use in forming their financial decisions and on the degree of financial openness. In the model, current output is affected by expectations of future output, real interest rates, and the terms of trade, but also by swings in foreign stock prices.

[1]Poterba (2000) and Davis and Palumbo (2001) offer overviews of the literature. Several papers estimate time series regressions on aggregate data with or without cointegrating relationships. Lettau and Ludvigson (2004) is a recent influential study that tries to quantify the wealth effect by separating between transitory and permanent innovations in wealth and consumption spending and finds a smaller effect than previously thought. Castelnuovo and Nisticó (2009) and Milani (2008), instead, estimate the size of the wealth effect in a theoretical closed-economy model to control for general equilibrium effects.

[2]E.g., Pichette and Tremblay (2003) estimate the wealth effect for Canada, Sierminska and Takhtamanova (2007) for Canada, Finland, and Italy, Funke (2004) for a sample of emerging countries, while Altissimo et al. (2005) provide a survey of several single-country estimates.

The model is estimated for a set of open economies – Australia, Canada, New Zealand, Ireland, Austria, and the Netherlands – which are thought to be potentially affected by one or more foreign stock markets. The ideal country in the estimation, i.e. one that most closely conforms to the theoretical model, would be an open economy that lacks an important domestic stock market, but which is characterized by a large fraction of residents that invest in equities, mainly abroad. None of the countries, with the possible exception of Ireland, is a flawless candidate; considering all of them, therefore, is important to interpret the results and to assess which factors may affect the size of wealth effects.

Most of the wealth that is invested abroad is typically directed to the U.S. Therefore, the U.S. stock market will usually represent the relevant foreign stock market to be considered in the estimation. But in some cases, financial markets situated in other countries (in the U.K. for Ireland, in the U.K. and Australia for New Zealand, and in Germany for Austria) also matter and they will be taken into account in the empirical analysis.

The models are estimated by likelihood-based Bayesian methods as in Milani (2007, 2008). In the estimation, the assumption of rational expectations is relaxed in favor of learning by economic agents. This is motivated by the necessity to induce the needed persistence in the model (as an alternative to assume habit formation in consumption and inflation indexation in price-setting), but especially by the results in Milani (2008), which shows that asset prices may play a large role through their influence on expectations about future real activity. The paper considers an explicit model of expectations formation, which allows me to disentangle the direct effect of asset prices on output from the indirect effect through expectations.

Results. The empirical estimates identify important wealth channels in Austria and in Ireland. The wealth effect is largest in Ireland, which is also the country in the sample in which foreign equity holdings are largest in relation to GDP and in which they comprise a larger fraction of the total equity portfolio. The data suggest no relevant wealth effect from foreign asset price fluctuations in Canada, Australia, the Netherlands, and New Zealand. The Bayesian model comparison exercise, in fact, indicates that, for these countries, the data favor the models in which the wealth effect is set to zero.

For all countries, however, foreign stock prices, still play a role by affecting domestic macroeconomic variables through their effect on expectations, particularly about future real activity. Including this expectational effect leads to improvements in model fit in all cases. Foreign stock prices are helpful in forecasting future output in the Netherlands, Canada, and Australia, while they do not matter in New Zealand. Through the direct wealth effect, but mainly through the indirect expectations-driven effect, shocks that originate in a large foreign stock market may have non-trivial effects on open economies, as they account for about 10 to 20% of output fluctuations in Austria, Ireland, and the Netherlands, while they have modest effects in other countries.

Contribution to the literature. The paper aims to contribute to the literature on the increasing international financial integration, by evaluating the effects that fluctuations in international stock markets may have on aggregate macroeconomic dynamics in open economies. While estimates of the wealth channel abound in a closed-economy context, corresponding estimates in an international dimension, which this paper aims to provide, are rare or missing.

The paper is related to the literature on international portfolio holdings: various studies investigate the determinants of bilateral positions (Portes and Rey, 2005, Lane and Milesi-Ferretti, 2008, Faruqee et al., 2004). Here the paper is agnostic about the causes of those investments patterns, while it analyzes, instead, the macroeconomic implications that large bilateral investment positions may have on the countries involved. The paper is also connected to recent works that stress the "valuation channel" of external adjustment (e.g., Obstfeld, 2004, Ghironi et al., 2006, Gourinchas and Rey, 2007) and to the literature that incorporates international equity trading in international macro models (e.g., Engel and Matsumoto, 2006, Devereux and Sutherland, 2007). The paper is less focused on the endogenous optimal portfolio choice and more on the aggregate wealth effect from fluctuations in value of given foreign stock portfolios.

Finally, the paper is related to the papers that estimate New Keynesian open economy models, but which typically abstract from any effect from asset prices (e.g., Bergin, 2006, Dennis et al., 2007, Smets and Wouters, 2002, Adolfson et al., 2007, Justiniano and Preston, 2010, and Rabanal and Tuesta, 2007). This paper investigates whether the omission of foreign financial variables represents a misspecification of the benchmark open economy model that is worth taking into account. In this way, the paper extends recent work by Castelnuovo and Nisticó (2009) and Milani (2008), who incorporate a wealth channel in closed-economy general equilibrium models and estimate its magnitude on U.S. data.

2. An Open Economy Model with International Wealth Effects

The model employed in the paper follows Di Giorgio and Nisticó (2007), who extend Yaari (1965) and Blanchard (1985)'s perpetual youth model to incorporate trade in risky equities and open economy features. This section sketches the main assumptions of the model, since a detailed derivation can be found in the original paper.

2.1. **Households.**

The world economy is populated by a continuum of households and firms in the interval $[0,1]$, that live and operate in two countries, Home and Foreign (denoted by H and F). Each period a new cohort of households enters the economy and faces a probability γ of dying in any period; one can think of γ more generally as the probability that economic agents exit the market in each period. Households derive utility from consumption goods and disutility from the total hours of labor they supply. They can invest in two types of financial assets: state-contingent assets, denominated in foreign currency, and equity shares that are issued by firms that operate under monopolistic competition and that are located in the foreign country.[3]

Households in each country maximize an intertemporal utility function by choosing their optimal levels of consumption C, labor supply N, and holdings of financial assets:

$$E_0 \sum_{t=0}^{\infty} \beta^t (1-\gamma)^t [\zeta_t \log(C_t^i(j)) + \log(1 - N_t^i(j))], \tag{2.1}$$

where $i = H, F$ denotes the country and j the cohort, β is the intertemporal discount factor, and ζ_t is an aggregate preference shock, subject to a sequence of budget constraints

$$\begin{aligned} C_t^H(j) + \frac{\varepsilon_t}{P_t^H} E_t \left[F_{t,t+1}^j B_{F,t+1}^H(j) \right] + \frac{\varepsilon_t}{P_t^H} \int_n^1 Q_{F,t}^*(i) Z_{t+1}^H(f,j) df \leq \\ \frac{W_t^H}{P_t^H} N_t^H(j) + \frac{1}{P_t^H} \int_0^n D_{H,t}^*(h,j) dh + \frac{\varepsilon_t}{P_t^H} \Omega_{F,t}^H(j), \end{aligned} \tag{2.2}$$

if living in the Home country, and

$$\begin{aligned} C_t^F(j) + \frac{1}{P_t^F} E_t \left[F_{t,t+1}^j B_{F,t+1}^F(j) \right] + \frac{1}{P_t^F} \int_n^1 Q_{F,t}^*(f) Z_{t+1}^F(f,j) df \leq \\ \frac{W_t^F}{P_t^F} N_t^F(j) + \frac{1}{P_t^F} \Omega_{F,t}^F(j), \end{aligned} \tag{2.3}$$

[3] Di Giorgio and Nisticó (2007) assume that markets are complete both nationally and internationally. They note that, although under complete markets trading in equity is redundant in a traditional representative agent model, in a perpetual youth setting trading in equity can have real effects due to the limited lifespan of economic agents.

if living in the Foreign economy, and subject to a No-Ponzi-game condition

$$\lim_{k\to\infty} E_t \left\{ F^j_{t,t+k}(1-\gamma)^k \Omega^i_{F,t+k}(j) \right\} = 0, \tag{2.4}$$

where ε_t denotes the nominal exchange rate in terms of units of domestic currency needed to purchase foreign currency, P^i_t is the Consumer Price Index in country i, $F^j_{t,t+k}$ is the stochastic discount factor between period t and $t+k$, $B^i_{F,t}(j)$ are holdings of state-contingent assets in country i expressed in F-currency, $1-n$ denotes the size of the foreign financial market, $Q^*_{F,t}(f)$ denotes the nominal price of equities (in F-currency), $Z^F_t(f,j)$ denote the equity shares issued by firms located in country F, W^i_t is the nominal wage rate in country i, $D^*_{i,t}(i',j)$ are dividends paid by firms that produce good i' in country i to cohort j's households, and where nominal financial wealth, denoted by $\Omega^i_{F,t}(j)$ and expressed in foreign currency equals

$$\Omega^i_{F,t}(j) \equiv \frac{1}{1-\gamma}\left[B^i_{F,t}(j) + \int_n^1 \left(Q^*_{F,t}(f) + D^*_{F,t}(f) \right) Z^i_t(f,j) df \right], \tag{2.5}$$

since it is assumed, as in Blanchard (1985), that an insurance contract exists so that the wealth that is carried over from the previous period is redistributed within the living cohort.

Each household in each country consumes a bundle of domestic and foreign goods $C^i_t(j) = \left[n^{\frac{1}{\theta}} C_{H,t}(j)^{\frac{\theta-1}{\theta}} + (1-n)^{\frac{1}{\theta}} C_{F,t}(j)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}$, with $C_{H,t}(j) = \left[\left(\frac{1}{n}\right)^{\frac{1}{\epsilon}} \int_0^n C_t(h,j)^{\frac{\epsilon-1}{\epsilon}} dh \right]^{\frac{\epsilon}{\epsilon-1}}$ and $C_{F,t}(j) = \left[\left(\frac{1}{1-n}\right)^{\frac{1}{\epsilon}} \int_n^1 C_t(f,j)^{\frac{\epsilon-1}{\epsilon}} df \right]^{\frac{\epsilon}{\epsilon-1}}$, and where $1-n$ denotes the fraction of imported goods in the consumption bundle,[4] $\theta > 0$ denotes the elasticity of substitution among domestic and foreign goods, and $\epsilon > 1$ denotes the elasticity of substitution among differentiated goods within the same country, which is assumed to be the same across countries.

The terms of trade are defined as $S_t \equiv \frac{P^i_{F,t}}{P^i_{H,t}}$, i.e. as the relative price of foreign-produced goods in terms of domestically-produced goods. The Law of One Price and the Purchasing Power Parity hold at each point in time: $P^H_t(i') = \varepsilon_t P^F_t(i')$ $i' = h, f$, $P^H_{i,t} = \varepsilon_t P^F_{i,t}$, and $P^H_t = \varepsilon_t P^F_t$.

2.2. **Firms.** Monopolistically-competitive firms in each country produce a continuum of differentiated goods. Each firm supplies good i', which is produced according to the production technology $Y_t(i') = A^i_t N_t(i')$, where $i' = h, f$, $i = H, F$, $N_t(i')$ is labor input, and A^i_t is a country-specific technology shock (the stock of capital can be thought of as fixed). Firms set prices à la Calvo: only a fraction $0 < 1 - \alpha^i < 1$ of firms in country i are allowed to change their price in a given

[4] In the model, $(1-n)$ is an index of openness for the Home country; for simplicity, the same openness coefficient is assumed for the real and financial side of the economy.

period. Firms face a common demand curve $Y_t(i') = Y_t^i \left(\frac{P_t^i(i')}{P_{i,t}^i}\right)^{-\epsilon}$ for their product, where Y_t^i is aggregate output in country i.

Each firm, therefore, faces the same decision problem and, if allowed to re-optimize, sets the common price $P_t^*(i')$ to maximize the expected present discounted value of future profits, subject to the demand curve constraint.

2.3. **Aggregate Dynamics.** By log-linearizing the model's first-order conditions around the symmetric steady state,[5] it is possible to derive the main laws of motion of the system. The macroeconomic dynamics in the domestic open economy can be characterized by the following set of equations

$$\begin{aligned} x_t^H &= \frac{1}{1+\psi}\widehat{E}_t x_{t+1}^H + \frac{\psi}{1+\psi}\left(s_t^F + (1-n)\theta\tau_t\right) \\ &\quad -\frac{1}{1+\psi}(i_t^H - \widehat{E}_t\pi_{t+1}^H - r_t^{n,H}) - (\theta-1)(1-n)\widehat{E}_t\Delta\tau_{t+1} \qquad (2.6) \\ \pi_t^H &= \widetilde{\beta}\widehat{E}_t\pi_{t+1}^H + \kappa^H(1+\varphi)x_t^H - (1-n)(\theta-1)\kappa^H\tau_t + u_t^H \qquad (2.7) \\ i_t^H &= \rho^H i_{t-1}^H + (1-\rho^H)[\chi_\pi^H\pi_{t-1}^H + \chi_x^H x_{t-1}^H + \chi_\tau^H\tau_{t-1}] + \varepsilon_t^H, \qquad (2.8) \end{aligned}$$

which represent a New Keynesian-style model, extended to include the impact of foreign stock prices and the terms of trade on the domestic economy.

Equation (2.6) is the log-linearized Euler equation arising from households' optimal choice of consumption and re-expressed in terms of the output gap, x_t^H. Output gap in period t depends on expected output gap in $t+1$, on the real stock price gap s_t^F, on the current and expected terms of trade τ_t, and on the ex-ante real interest rate, with i_t, π_t, r_t^n denoting the nominal interest rate, inflation, and the (unobserved) natural interest rate.[6]

The wealth effect from international stock market fluctuations to the domestic economy depends on the reduced-form term $\frac{\psi}{1+\psi}$, in which ψ is a composite function of structural coefficients, which positively depends on the probability of exiting the market γ and on the openness term $(1-n)$, i.e. $\psi \equiv \gamma(1-n)\frac{1-\beta(1-\gamma)}{(1-\gamma)}\frac{\Omega_F}{P^F Y}$. A higher γ, indicating a shorter planning horizon by agents, therefore, leads to a larger wealth channel; it reduces, instead, the degree of intertemporal consumption smoothing and the sensitivity of output to real interest rates. The last term $\frac{\Omega_F}{P^F Y}$ is pinned down

[5]See appendix in Di Giorgio and Nisticó (2007) for a step-by-step derivation.

[6]The output gap is defined as the percentage deviation of total output Y_t^H from $Y_t^{H,n}$, the natural level of output, i.e. the equilibrium level of output under flexible prices. Similarly, the real stock price gap and the terms of trade gap are defined as percentage deviations from their flexible-price equilibrium levels.

in steady state by the relation $\frac{\Omega_F}{P^F Y} = \left(\frac{\mu-1}{\mu}\right)\left(\frac{1+r}{r}\right)$, where $\mu \equiv \frac{\epsilon}{\epsilon-1}$ is the steady-state mark-up of prices on marginal costs and r is the steady-state real interest rate.

Equation (2.7) is a New Keynesian Phillips curve, in which domestic inflation π_t^H depends on expected inflation in $t+1$, on the domestic output gap, and on the terms of trade. Here $\tilde{\beta} \equiv \frac{\beta}{1+\psi}$ and $\kappa^i \equiv \frac{(1-\alpha^i)(1-\alpha^i\tilde{\beta})}{\alpha^i}$, hence, a higher γ will cause inflation to depend less on expectations and more on current real activity and terms of trade.

Equation (2.8) denotes a Taylor rule, which describes the monetary policy implemented by the central bank in the domestic economy. The central bank reacts to domestic inflation, output gap, and the terms of trade (no response is assumed with respect to the foreign stock price gap); χ_π^H, χ_x^H, and χ_τ^H are the feedback coefficients, while ρ^H accounts for the degree of policy inertia.

The real foreign stock price gap and the terms of trade evolve according to:

$$\begin{aligned} s_t^F &= \widetilde{\beta}\widehat{E}_t s_{t+1}^F + (1-\widetilde{\beta})\widehat{E}_t\left(x_{t+1}^F + n\tau_{t+1}\right) - \left(i_t^F - \widehat{E}_t\pi_{t+1}^F - r_t^{n,F}\right) \\ &\quad -n\widehat{E}_t\Delta\tau_{t+1} - \frac{\widetilde{\beta}Y/Q^F}{\mu}\widehat{E}_t\left[(1+\varphi)x_{t+1}^F + n(\theta-1)\tau_{t+1}\right] + e_t \qquad (2.9) \\ \tau_t &= \widehat{E}_t\tau_{t+1} + \left(i_t^F - \widehat{E}_t\pi_{t+1}^F - r_t^{n,F}\right) - \left(i_t^H - \widehat{E}_t\pi_{t+1}^H - r_t^{n,H}\right) \\ &\quad +\phi_t, \qquad (2.10) \end{aligned}$$

where equation (2.9) is derived from log-linearization of the asset-pricing equation that arises from the household's optimization problem and it states that the foreign stock price gap is affected by the expected stock price gap, the foreign output gap, the terms of trade, and by the foreign ex-ante real interest rate. The parameter $\varphi \equiv \frac{N}{1-N}$ denotes the inverse of the Frisch elasticity of labor supply in steady-state; N, μ, Y, and Q^F all refer to steady-state values. Equation (2.10) describes the dynamics of the logarithm of the terms of trade, which also depends on expectations as well as on the real interest rate differential.

The foreign economy, in which the relevant stock market is situated, can be represented by the following laws of motion

$$\begin{aligned} x_t^F &= \frac{1}{1+\psi}\widehat{E}_t x_{t+1}^F + \frac{\psi}{1+\psi}\left(s_t^F - n\theta\tau_t\right) \\ &\quad -\frac{1}{1+\psi}(i_t^F - \widehat{E}_t\pi_{t+1}^F - r_t^{n,F}) + (\theta-1)n\widehat{E}_t\Delta\tau_{t+1} \qquad (2.11) \\ \pi_t^F &= \widetilde{\beta}\widehat{E}_t\pi_{t+1}^F + \kappa^F(1+\varphi)x_t^F + n(\theta-1)\kappa^F\tau_t + u_t^F \qquad (2.12) \\ i_t^F &= \rho^F i_{t-1}^F + (1-\rho^F)[\chi_\pi^F\pi_{t-1}^F + \chi_x^F x_{t-1}^F + \chi_{s^F}^F s_{t-1}^F] + \varepsilon_t^F, \qquad (2.13) \end{aligned}$$

which characterize aggregate demand, aggregate supply, and monetary policy, and are a mirror image of the corresponding relationships in the domestic economy.

The variables $r_t^{n,i}$, u_t^i, ε_t^i, e_t, and ϕ_t denote domestic and foreign shocks to the natural interest rate, cost-push shocks to inflation, monetary policy shocks, and shocks to the foreign stock market and to the terms of trade relation ($r_t^{n,i}$, u_t^i, and ϕ_t are assumed to evolve as AR(1) processes).

The dynamics of macroeconomic variables in the home country is, therefore, affected by the stock price dynamics in the foreign country, in which, we assume, the largest financial market is situated. The magnitude of the effect is an empirical question, on which the paper will try to shed light.

Expectations in the model can deviate from the conventional hypothesis of rational expectations: $\widehat{E}_t$ here denotes subjective (near-rational) expectations and can differ from the mathematical expectations operator E_t, conditioned on all the available information (to check that the results are not due to specific assumptions about the expectation formation mechanism, however, all models have also been estimated under rational expectations, as discussed later in the paper). The next section describes in more detail the assumed expectations formation.[7]

2.4. **Expectations.** The assumption of rational expectations is relaxed, by assuming that economic agents form near-rational expectations and learn about economic relationships over time (see Evans and Honkapohja, 2001, for a treatise on learning models, and Sargent, 1999, for an influential application).

Agents in the Home country H use a linear model as their Perceived Law of Motion (PLM)

$$Z_t^H = a_t^H + b_t^H Z_{t-1}^H + e_t, \tag{2.14}$$

where $Z_t^H \equiv [x_t^H, \pi_t^H, i_t^H, \tau_t, s_t^F]'$, a_t^H is a 5×1 vector and b_t^H is a 5×5 matrix of coefficients. Agents are assumed not to know the relevant model parameters; therefore, they use historical data to learn them over time. Each period, they update their estimates of a_t^H and b_t^H according

[7] One might wonder about the implications of modifying the expectations assumptions directly on the log-linearized laws of motion obtained under rational expectations, rather than from the primitives of the model (i.e., in equation 2.1). Honkapohja et al. (2003) discuss this issue at length and show that the two approaches (which are commonly referred to as Euler-Equation learning versus Infinite-Horizon learning in the adaptive learning literature) lead to identical model equations under mild assumptions (mainly, that agents know that the market clearing condition, $Y_t = C_t$ in this case, holds at all times). Preston (2005) and Milani (2006) provide examples of models with infinite-horizon learning.

to the constant-gain learning formula

$$\widehat{\phi}_t^H = \widehat{\phi}_{t-1}^H + \mathbf{\overline{g}}^H \left(R_t^H\right)^{-1} X_t^H \left[Z_t^H - \left(X_t^H\right)' \widehat{\phi}_{t-1}^H\right] \quad (2.15)$$

$$R_t^H = R_{t-1}^H + \mathbf{\overline{g}}^H \left[X_t^H \left(X_t^H\right)' - R_{t-1}^H\right] \quad (2.16)$$

where (2.15) describes the updating of the learning rule coefficients collected in $\widehat{\phi}_t^H = \left((a_t^H)', vec(b_t^H)'\right)'$, and (2.16) characterizes the updating of the precision matrix R_t^H of the stacked regressors $X_t^H \equiv \left\{1, x_{t-1}^H, \pi_{t-1}^H, i_{t-1}^H, \tau_{t-1}, s_{t-1}^F\right\}_0^{t-1}$. $\mathbf{\overline{g}}^H$ denotes the constant gain coefficient, which governs the weight given to old versus recent observations.

I assume that economic agents dispose of information only up to $t-1$ when forming expectations for next period.[8]

Therefore, they use (2.14) and the updated parameter estimates in (2.15) and (2.16) to form their expectations for $t+1$ as

$$\widehat{E}_{t-1} Z_{t+1}^H = a_{t-1}^H \left(1 + b_{t-1}^H\right) + \left(b_{t-1}^H\right)^2 Z_{t-1}^H, \quad (2.17)$$

which can be substituted in (2.6) to (2.10) to obtain the Actual Law of Motion of the economy (ALM):

$$\begin{aligned} \xi_t &= A_t + F_t \xi_{t-1} + G w_t \quad (2.18) \\ Y_t &= H \xi_t \end{aligned}$$

where $\xi_t = [x_t^H, \pi_t^H, i_t^H, \tau_t, s_t^F, x_t^F, \pi_t^F, i_t^F, r_t^{n,H}, u_t^H, r_t^{n,F}, u_t^F, e_t, \phi_t]'$ and Y_t collects the observable variables $\left[x_t^H, \pi_t^H, i_t^H, \tau_t, s_t^F, x_t^F, \pi_t^F, i_t^F\right]$, and which displays (2.6) to (2.10) in state-space form. A_t, F_t, and G depend on both structural parameters and agents' beliefs (which make A_t and F_t time-varying); H is an 8×14 matrix of zeros and ones, which simply selects observables from the state vector ξ_t. Given a value of the gain $\mathbf{\overline{g}}^H$ and initial beliefs $\widehat{\phi}_{0|0}^H$, the learning process of the agents in (2.15)-(2.16) and the corresponding expectation series (2.17) over the sample can be obtained and inserted into (2.18). Given those expectations, the system remains linear; moreover, the exogenous shocks w_t are assumed to be Normally-distributed and, therefore, the Kalman filter can be used to obtain the likelihood of the system at each iteration of the Metropolis-Hastings algorithm, which will be, instead, used to sample from the posterior distribution in the Bayesian estimation. The main innovation due to learning in (2.18) is that the matrices A_t and F_t are time-varying; in the estimation, A_t and F_t are, therefore, recursively updated at each step of the

[8]The $(t-1)$-information assumption is typical in the learning literature as it permits to avoid simultaneity issues.

Kalman filter over the sample, based on the most recent updates in the agents' beliefs from (2.15). The Kalman filter is used to estimate models with learning by economic agents also in Milani (2007, 2008), Slobodyan and Wouters (2009), and Sargent, Williams, and Zha (2006).

In the estimation, I will estimate the fully-structural model for the domestic economy, but I will adopt an unrestricted VAR for the foreign sector (that is, equations 2.9, 2.11, 2.12, and 2.13, will be replaced by a VAR in the same endogenous variables for the foreign country).[9] In this way no restriction on the size of the wealth effects across countries is imposed, i.e., in particular, no restriction that γ should be the same across countries (as this is unlikely to be satisfied in the data).[10]

3. Estimation

3.1. **Choice of the Countries.** I estimate the model using quarterly data for the following open economies (the countries that are taken as the relevant foreign economy, in which the largest stock market is situated, are listed in parenthesis): Canada (U.S.), Australia (U.S.), New Zealand (U.S., U.K., and Australia), Ireland (U.S. and U.K.), Austria (Germany and U.S.), and the Netherlands (U.S.).

The ideal country, i.e. one that resembles the Home economy in the theoretical model, is an open economy that possibly lacks a highly-developed financial market and in which, as a consequence, a large part of the population invests in a larger foreign market. For the international wealth effect to be sizeable, the level of stock market participation should be adequate and foreign equity holdings should possibly represent a large part of the investment portfolio.

Among the chosen economies, Canada, Ireland, and the Netherlands all have large ratios of foreign equity to GDP, while Australia, Austria, and New Zealand have somewhat smaller levels (see Sorensen et al., 2007).

Ireland seems an ideal choice: a very small part of wealth is invested in the Irish stock market, while most is directed to the U.S. (and in slightly smaller magnitude to the U.K.) market. The foreign equity to GDP ratio is large (142%) and stock market participation is reasonable (18%).

[9]The lag length is chosen using Schwartz' Bayesian Information Criterion.

[10]While estimating both the domestic and the foreign economies as structural poses no particular complication, it may bias the estimate of the wealth effect for the home country. Since this is the main parameter of interest, I have chosen, therefore, to use a well-fitting model as an unrestricted VAR to characterize the dynamics of the relevant foreign variables (this is not uncommon in estimated open economy DSGE models, e.g., Adolfson et al., 2007).

Since all requirements are satisfied, we can expect the cross-country wealth effect to be larger in Ireland than in other countries.

Canada, Australia, and New Zealand are common choices as open economy countries; therefore, I also include them in the estimation. Canada has a developed internal stock market, but still a large part of wealth is invested in the U.S. (somewhat surprisingly, the correlation of real equity returns between the two markets seems also small, see Faruqee et al., 2004); the same is true for Australia. Australia and New Zealand have high participation rates (40% and 30%, see Guiso et al., 2006), but, on the negative side, they have relatively smaller foreign equity to GDP ratios (17% for Australia and 18% for New Zealand), due to a sizeable home equity bias (foreign equities form only 17% of Australian portfolios, and 30% for New Zealand).

Austria is also a good candidate country for the empirical analysis since a large fraction of equity wealth is invested in foreign equities (61%), mostly in Germany and the U.S. It has, however, a lower stock market participation rate (7-8%) than other countries, which can limit the magnitude of the wealth effect. The Netherlands similarly have a large fraction of foreign equity holdings (62% out of total equity), which is sizeable also in relation to domestic GDP (61%), and a reasonable participation in the stock market.

To check the geographic patterns of bilateral investments, I use the data on foreign equity investments, taken from the IMF Coordinated Portfolio Investment Survey (CPIS). From the geographic breakdown of equity investments, it is apparent that, for most countries, financial investments are directed toward the U.S. One exception is Austria, since Germany attracts a slightly larger fraction than the U.S. For Ireland and New Zealand, the U.S. market still attracts the largest part of wealth, but the U.K. (for Ireland) and the U.K. and Australia (for New Zealand) also matter. Therefore, in the empirical analysis, for Austria, Ireland, and New Zealand, the foreign sector will not be given by a single country, but it will be calculated as a weighted average of different countries, with the weights given by the relative percentage of equity holdings in each country.

3.2. **Data.** The model is estimated to fit the series on output gap, the inflation rate, and the nominal interest rate, for both the domestic open economy and for the foreign economy, as well as on the foreign real stock price gap, and on the (log) terms of trade (in deviation from a natural level).

The output gap for each country is computed by detrending the log of the Real GDP series using the Hodrick-Prescott filter, inflation is defined as the quarterly change in the GDP implicit price deflator,[11] the policy instrument consists of a short-term nominal interest rate, and the (log) terms of trade for each country are given by the log price of imports minus the log price of exports (these consist of multilateral terms of trade, since the bilateral series is not available), taken in deviation from the Hodrick-Prescott trend. The real stock price gap, when the U.S. is the relevant foreign economy, is computed as the S&P 500 index deflated using the GDP deflator and then detrended using the Hodrick-Prescott filter. For Austria, the real stock price gap is calculated as a weighted average between the U.S. and German real stock price gap series, for Ireland as the weighted average between the U.S. and U.K. series, for New Zealand, as the weighted average between the U.S., Australia, and the U.K. (for Germany, the U.K., and Australia, I use the OECD Share Price Index - All Shares series).[12] All data have been obtained from the DRI-Global Insight database. The sample is 1982:I-2007:III for Canada (since 1982 reflects the abandonment of the money targeting experiment by the Bank of Canada), 1982:I-2007:II for Australia, 1987:III-2007:I for New Zealand, 1983:I-2006:II for Ireland, 1988:I-2007:II for Netherland, and 1991:I-2007:I for Austria.

The vector Θ collects the coefficients that need to be estimated:

$$\Theta = \left\{\gamma, 1-n, \theta, \alpha^H, \rho^H, \chi_\pi^H, \chi_x^H, \chi_\tau^H, \rho_r^H, \rho_u^H, \rho_\phi^H, \widehat{\mathbf{g}}^H, Q^H, \Phi^F, \Sigma^F\right\} \tag{3.1}$$

where Q^H collects the standard deviation of domestic demand, supply, policy, and terms of trade shocks, , Φ^F collects all the foreign VAR coefficients, and Σ^F denotes the foreign VAR variance-covariance matrix.

Some of the coefficients have been fixed (they may be thought as having dogmatic priors with zero variance): the discount factor β is fixed at 0.99, μ is chosen to imply a 25% mark-up of prices on marginal costs, r, the steady-state real interest rate is fixed for each country at its sample average, N the fraction of working time in steady-state is fixed at 1/3 (which implies a value for φ equal to 1/2).

[11]For Ireland, instead, for lack of long series on GDP and its price deflator, I use data on industrial production and the CPI to calculate the output gap and the inflation rate.

[12]The data to compute the weighted averages are taken from the IMF CPIS survey. For Austria, the weights are roughly 57% for Germany and 43% for the U.S., for Ireland, 57% for the U.S. and 43% for the U.K., and for New Zealand, 56% for the U.S., 30% for Australia, and 14% for the U.K. I have also estimated the models using only a single foreign country for those countries (the one which attracts the largest fraction of wealth). The sizes of the wealth and expectations effect are not sensitive to these modifications.

The model is estimated by likelihood-based Bayesian methods. The estimation technique follows Milani (2007), who extends the approach described in An and Schorfheide (2007) to permit the estimation of DSGE models with near-rational expectations and learning by economic agents.[13] The results may depend on the assumed learning process, if this is imposed a priori. Therefore, here, I also estimate the learning process (which depends on the constant-gain coefficient) jointly with the rest of structural parameters of the economy. In this way, the best-fitting learning process is extrapolated from actual data along with the best-fitting preference and policy parameters.

Adding learning in the model carries a number of advantages. First, as in Milani (2007), learning substantially improves the ability of the model to fit the data, by including lags in the model equations, which are essential to capture the persistence in macroeconomic data (in this respect, it is an alternative to introducing several frictions in the model, as habit formation in consumption, automatic inflation indexation, rule-of-thumb behavior, and so forth), and by incorporating time-varying parameters in the estimation in a very parsimonious way (the extent of the time variation, in fact, depends on a single estimated parameter, the gain $\widehat{\mathbf{g}}$). Moreover, the model with learning allows the researcher to disentangle the direct effect of asset price fluctuations on the economy from a possibly more sluggish effect that operates through expectations.

I use the Metropolis-Hastings algorithm to generate draws from the posterior distribution. I consider 300,000 draws, discarding the first 25% as initial burn-in.

3.3. **Priors.** The priors for the model parameters are described in Table 1. I assume a Beta prior for γ (which ensures that the coefficient remains within the [0,1] bounds), the main parameter of interest, which affects the size of the cross-country wealth effect.[14] I assume Beta prior distribution also for the openness term $1-n$, with different means for each country, which are chosen to match the percentage share of foreign equities in the countries' aggregate portfolios (using the values in Sorensen et al., 2007) and with standard deviation 0.2 (therefore, instead of fixing this parameter, I prefer to estimate it from the data, using a prior with rather large uncertainty),[15] except for

[13]To initialize the learning algorithm in (2.15) and (2.16), I use pre-sample data when available. When no previous data are available, I start from initial beliefs equal to 0 for each PLM coefficient other than the autoregressive terms and equal to 0.8 for the autoregressive terms. I will later check the robustness to different initial conditions for such cases.

[14]I have also estimated the model for each country under a Uniform [0,1] prior for γ. The results are not affected, as the data happen to be very informative about this parameter.

[15]I have also performed estimations centering the prior for $1-n$ at the fraction of imports over GDP, instead. The estimated magnitudes of the wealth effects are not sensitive to this choice.

Ireland in which the standard deviation is 0.05 to maintain a meaningful distribution, and Gamma distribution for the elasticity among differentiated goods θ with mean 1.5. I use a Normal prior for the monetary policy feedback coefficients to inflation, output gap, and terms of trade gap. I assume a Uniform prior distribution for the constant gain coefficient. Finally, Beta distributions are used for all the autoregressive coefficients and for the Calvo price stickiness parameter, and Inverse Gamma distributions for the standard deviations of the shocks.

[Insert Table 1 about here]

4. Empirical Results

The posterior estimates for the model with wealth effects for all countries are reported in Table 2. For each country, I have also estimated models in which either the wealth effect or the effect of stock prices on future expectations, or both, are shut down. Table 3 shows the log marginal likelihoods for the various cases, which permit to identify which feature is necessary to obtain the best fit of the data for each country.

[Insert Table 2 about here]

[Insert Table 3 about here]

4.1. **Size of the Wealth Channel.** One of the main parameters of interest in the estimation is γ, the probability of leaving the market (also interpreted as the inverse of the agents' planning horizon), since it crucially affects the size of the wealth effect from foreign stock price fluctuations to domestic output. The data are very informative about the distribution of this parameter: although the results in Table 3 are obtained under an informative Beta prior, the posterior estimates are comparable when the estimation is repeated with a diffuse $[0, 1]$ Uniform distribution. The posterior mean estimates for γ equal 0.0136 for the Netherlands, 0.014 for Austria, 0.0197 for Canada, 0.022 for Ireland and New Zealand, and 0.026 for Australia. These estimates would imply planning horizon lengths for households's consumption and saving decisions ranging from $1/\gamma \approx$ 9-10 years for Australia to 18 years in the Netherlands.

Another crucial coefficient that influences the magnitude of the wealth effect is the estimated country's openness to foreign financial markets. This parameter was given a prior distribution centered at the ratio of foreign equity holdings as a fraction of total equity investments for each country. As expected, Ireland is by far the country that is more open to foreign investments in equity shares: the posterior mean for $1-n$ equals to 0.938. New Zealand, Austria, and the Netherlands are also significantly open (their mean estimates equal 0.326, 0.491, and 0.504), while Canada and, especially, Australia exhibit larger degrees of home bias in equity investments (the posterior means equal 0.242 for Canada and 0.123 for Australia).

It is reassuring to notice that the data do not push toward shutting down the open economy features of the model. Not only $1-n$ is not led to 0, but also the estimates for θ, the elasticity of substitution between home and foreign goods are sensible: they fall not far from 1 for Canada, Australia, Austria, and the Netherlands; the elasticity is smaller in New Zealand (0.483) and Ireland (0.544).

Turning to the other structural coefficients, the degree of price stickiness is high in all countries: the estimates indicate that prices remain fixed on average four or more quarters. Although these estimates are on the high side of the spectrum and probably not entirely consistent with firm-level evidence, they are not uncommon in this kind of macro models. The estimates of the country-specific Taylor rules indicate that national monetary policies have respected the "Taylor principle" and are not far from the typical estimates obtained for post-1984 U.S. or Euro area policy rules. There is no evidence of a response to the terms of trade variable: this feedback coefficient is estimated with some uncertainty and the 95% HPD intervals always assign large probability to the case of a zero response (the only possible exception may be Australia).

The estimates of the constant gain coefficient, which governs the speed at which agents are learning in each economy, fall between 0.08 (for New Zealand) and 0.117 (for Ireland). These numbers are expected to differ as the degree of structural change that agents anticipate in these economies is also likely to differ (i.e., if agents perceive a high probability of future structural breaks, they will be better off adopting a higher gain, which allows them to weigh more heavily recent observations, compared to old, possibly outdated, information).

From the structural estimates, it is possible to derive the implied reduced-form wealth effect (the coefficient $\frac{\psi}{1+\psi}$). The estimates imply a reduced-form wealth effect with posterior mean equal to 0.0035 for Canada (the smallest), 0.0039 for New Zealand, 0.0041 for Australia, 0.0046 for Austria, and 0.0049 for the Netherlands. The country that experiences the largest wealth effect from fluctuations in foreign (U.S. and U.K. in this case) stock prices is Ireland: here the reduced-form short-run wealth effect equals 0.0235. Looking at the 95% HPD intervals, the wealth effect falls between 0 and about 0.015 for most countries, and between 0 and 0.08 for Ireland.

Periods in which the real stock price deviates 50 percentage points above or below its "*natural*" level (which have not been uncommon, e.g. the stock market bust in the U.S. and U.K. in 1973-74 and the "New Economy" boom) would imply a deviation of output of 0.175%, on average, from potential output for Canada, of 0.195% for New Zealand, of 0.205% for Australia, of 0.23% for Austria, of 0.245% for the Netherlands, and of 1.175% for Ireland, through a direct wealth effect. The magnitudes are usually modest, but large stock market fluctuations can still have significant effects, at least for Ireland.[16]

An indirect effect through which stock prices influence future output expectations may, however, increase the overall impact.

4.2. **Wealth and Expectations Effect from Foreign Stock Price Fluctuations.** Foreign stock prices affect domestic macroeconomic variables for the sample of countries considered through two channels: the direct wealth effect, whose size has been estimated in the previous section, and an expectations-driven effect, through the impact on equation (2.14).

But are the wealth and expectations effect necessary to fit the data?

Table 3 presents the outcomes of a Bayesian model comparison exercise, in which I estimate, for each country, models in which both the wealth and expectations effects are included (these give the estimates reported in Table 2), in which the direct wealth channel is shut down (fixing $\gamma = 0$), or the expectations effect of foreign stock prices is shut down (fixing the coefficients on s_{t-1}^F to 0 in 2.14).[17] The table shows the log marginal likelihoods, calculated using Geweke's modified harmonic mean approximation.[18]

The wealth channel seems to be an important feature of the data for Ireland and Austria. Fluctuations in the U.S. and U.K. stock market, for Ireland, and in the U.S. and German stock market, for Austria, have a significant effect on output in these countries. For both countries, the preferred specification includes both the wealth and the expectations effect.

[16]For Canada, Australia, and Ireland, in which the estimation sample started in the early 1980s, I have repeated the estimation with only post-1995 data. After 1995, in fact, the degree of financial integration has increased much more rapidly and may lead to different estimates. The implied wealth effects are, however, similar for Australia and Ireland, and marginally higher for Canada: 0.0053 rather than 0.0035.

[17]The specifications in which both the wealth and expectations effect are shut down at the same time are never favored by the data and, therefore, not reported in the table.

[18]The log marginal likelihoods provide an appealing measure of fit since they automatically penalize for the number of parameters to be estimated and they can be shown to be related to the models' out-of-sample predictive ability.

For the remaining countries, the data favor the specification with no wealth effect. Overall, the results suggest cross-border wealth effects that matter in countries characterized by large foreign equity positions as Ireland and Austria, as one would expect; in countries in which home bias is still important (as Canada, Australia, and New Zealand), there is no significant wealth effect.

For all countries, however, foreign stock markets still play a role by influencing domestic expectations, particularly about future output gaps (the models' fit, in fact, worsens when foreign stock prices are excluded).

4.2.1. *Evolving Beliefs.* Figure 1 shows the estimated agents' beliefs about their perceived effect of foreign stock price fluctuations on domestic output for the countries in the sample. The size of these reduced-form coefficients is substantially larger than the estimated direct wealth effect in Table 2.

[Insert Figure 1 about here]

By updating their beliefs as estimated, agents can improve their forecasts. Table 4, in fact, compares the sample mean squared errors (MSE) for each country in the case in which agents are assumed to use the information provided by the foreign stock price gap (as in 2.14) with those when they don't. The table reports the relative MSE. I also compute Diebold and Mariano (1995)'s statistic to test for equal forecast accuracy. Adding foreign stock prices to the PLM leads to improvements in output gap forecasts for all countries, except New Zealand. The Diebold-Mariano test leads to rejection of the null hypothesis of equal forecast accuracy at the 5% significance level for Australia and the Netherlands and at the 10% level for Canada; the null cannot be rejected for New Zealand and Ireland.

[Insert Table 4 about here]

4.3. **Sensitivity to Expectation Formation Mechanism.** The results have been so far derived under the assumption that agents form near-rational expectations and are learning. Most estimated DSGE models, however, retain the more conventional assumption of rational expectations. Therefore, to assess the sensitivity of the results to the modeling of expectations, I re-estimate the model for each country under rational expectations. These specifications are estimated under two scenarios: one which incorporates the international wealth channel and another in which the wealth channel is shut down (by setting $\gamma = 0$).[19]

The estimates of the main parameter of interest, γ, are similar in the cases of learning and rational expectations. Under rational expectations, the posterior mean estimates for γ equal 0.017 for Canada, 0.016 for Australia, 0.030 for New Zealand, 0.036 for Ireland, 0.011 for Austria, and 0.012 for the Netherlands, which are comparable to those reported in Table 2 for the learning model. The estimated degrees of openness, denoted by $1 - n$ in the model, are also similar: 0.293 for Canada, 0.159 for Australia, 0.337 for New Zealand, 0.936 for Ireland, 0.551 for Austria, and 0.512 for the Netherlands (the full set of posterior estimates is omitted to save space). Therefore, the overall magnitude of the wealth channels is comparable.

Table 3 compares the fit of the models under rational expectations and under learning, by reporting the log marginal likelihoods. For the two specifications under rational expectations, the models without a wealth channel are preferred in all countries except Ireland. For Ireland, including the cross-country wealth channel from U.S. and U.K. stock price fluctuations leads to an improvement in model fit. This finding is consistent with the results under learning, which also pointed to Ireland as the example in which the cross-country wealth channel was stronger.

The model comparison exercise, however, consistently reveals that specifications under learning fit the data substantially better than do those under rational expectations. Therefore, the conclusions discussed in the previous section for the model under learning are not overturned by assuming a different model of expectation formation.

4.4. **Sensitivity to Alternative Initial Beliefs.** The learning processes have been initialized using pre-sample data when available. In the cases of New Zealand and the Netherlands, however, pre-sample data were not available and, therefore, initial beliefs $\widehat{\phi}^H_{0|0}$ were assumed to equal zero for all coefficients except for the autoregressive coefficients in each equation, which were set equal to 0.8. Here, I re-estimate the models with initial beliefs for the autoregressive coefficients now equal to 0.5 and 0. In the case of Austria, estimation on pre-sample data was used to initialize the learning process, with the exception of the interest rate equation, since pre-sample data on

[19]Under rational expectations, the paper doesn't separate between the direct wealth effect and the expectation effect, since expectations are univocally determined by the structure of the model.

the policy instrument were missing. The estimation is, therefore, also repeated for the Austrian case under alternative initial beliefs.

The results are unchanged. The probability of exiting the market γ has posterior mean equal to 0.023 when the initial persistence coefficients are set to 0 and equal to 0.022 when they are set to 0.5 for New Zealand (0.022 in the baseline case), equal to 0.0132 and 0.0137 for the Netherlands (0.0136 in the baseline case), and to 0.016 for Austria (0.014 in the baseline case). The estimated gain coefficients are also similar (0.079 in both cases for New Zealand, 0.11 and 0.113 for the Netherlands, and 0.09 for Austria). The remaining posterior estimates are also almost identical.

4.5. **Impulse Responses.** Figure 2 shows the impulse response functions of the domestic output gap in each country to a positive one-standard deviation foreign stock price shock.[20] The impulse responses refer for each country to its best-fitting estimated model specification, as found in Table 3.[21]

[Insert Figure 2 about here]

Positive foreign stock price shocks lead to improvements in the output gap in the short to medium-run for most countries. The output response is larger and more immediate in Ireland, since the direct wealth effect has been estimated as much stronger in this country. The shock leads to a quite rapid jump in output also in Austria. The impulse responses for Canada, Australia, and the Netherlands appear, instead, more gradual and hump-shaped: the effect of stock price shocks, in fact, in those countries are not due to a direct wealth channel (as $\gamma = 0$), but only to the slow-moving learning dynamics. There is basically no response in New Zealand.[22]

4.6. **Variance Decomposition.** As seen, even if the direct wealth effect is small for most countries, foreign stock prices can still play a role in the economy by leading to revisions in future output expectations. I investigate the importance of foreign stock prices by looking at the forecast error variance decomposition. Figure 3 shows the percentage of variance in the domestic output

[20] The figure displays the average impulse responses over the sample, which are time-varying in the model as a result of learning dynamics.

[21] Stock price shocks are identified using a Cholesky decomposition in the foreign VAR, with stock prices ordered last (i.e., under this identification scheme, stock prices are assumed to respond contemporaneously to developments in the economy, but output, inflation, and interest rates only react with a lag to stock price changes); this ordering is conservative as it leads to a likely underestimation of the effect of stock price shocks.

[22] For New Zealand, even learning does not play a large role. New Zealand's output gap, in fact, displays a slightly negative correlation with past foreign stock price gaps, which therefore, as also found in Table 4, are not useful leading indicators of future economic activity as they are for other countries.

gaps for each country that, on average, can be accounted for by shocks that originate in the foreign stock market.

[**Insert Figure 3 about here**]

Foreign stock price shocks can account for a sizeable portion of output fluctuations in Austria and Ireland, which were the only two countries for which the data suggested an important wealth channel, and in the Netherlands (stock price shocks explain between 10 and 20% of the variance). Their role is smaller in Canada, Australia, and New Zealand.

Figure 4 shows, instead, the percentage of variance explained by foreign stock price shocks as it varies over time starting from 1990, for the countries in which they seem to be more important. The percentage is increasing in Ireland and the Netherlands, starting from around 2000. The international stock markets bust in 2001-2003 appears to have played a role in slowing down the economy in these three countries.

[**Insert Figure 4 about here**]

For most countries, the correlation between foreign stock price gap and domestic output gap is positive (quite large for Ireland, Austria, and the Netherlands, less so for Canada and Australia). The wealth effect (in particular for Ireland and Austria in which it was found to be a significant feature of the data), therefore, is likely to be procyclical, rather than countercyclical, which should be preferred if foreign investments were mainly chosen to attain higher degrees of risk sharing. The observed investment patterns, however, do not entirely conform with the recommendation of models of international risk sharing: the international portfolio holdings' data, in fact, show that people often invest in stock markets located in countries with a similar business cycle (as Germany for Austria, the U.K. for Ireland, or the U.S. for Canada).[23]

5. Conclusions

This paper has examined one potential implication of the rapid increase in international financial integration that has occurred in recent years: the possibility of positive cross-border wealth effects from foreign equity holdings, which can affect macroeconomic dynamics in open economies.

[23]Portes and Rey (2005) and Lane and Milesi-Ferretti (2008) show that these investment patterns may be largely explained by variables that proxy for informational frictions, while there is only weak support for the diversification motive.

The estimates suggest a positive and rather large wealth effect in Ireland from fluctuations in the U.S. and U.K. stock markets. The result is sensible as Ireland has the largest foreign equity to GDP ratio and the largest amount of foreign equities in the total portfolio, among the countries in the sample. There is a significant, but smaller, wealth effect from foreign stock prices also for Austria. The data do not support the existence of direct wealth channels for Canada, Australia, New Zealand, and the Netherlands.

But for all countries in the sample, foreign stock prices still play a role through an effect that operates through the formation of domestic expectations, particularly regarding future real activity. The effect is especially relevant in the Netherlands, quite important in the other countries, and almost nil for New Zealand.

The impact of foreign stock price fluctuations can be expected to intensify as the degree of financial integration increases further. The cross-border wealth effects may also evolve over time as the geographic distribution of bilateral positions among countries changes.

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		Prior Distribution			
Description	Parameter	Distr.	Support	Prior Mean	95% Prior Prob. Interval
Prob. of Leaving the Mkt.	γ	*Beta*	$[0,1]$	0.05	[0.0038,0.15]
Discount Rate	β	-	-	0.99	-
Openness	$1-n^i$	B	$[0,1]$	$\frac{Foreign\ Equity_i}{(Total\ Equity_i)}^*$	[depends on i]
Elast. H vs. F Goods	θ	Γ	$\mathbb{R}^+$	1.5	[0.18,4.27]
Calvo Price Stick.	α	B	$[0,1]$	0.5	[0.09,0.91]
MP Inertia	ρ	B	$[0,1]$	0.8	[0.459,0.985]
MP Inflation feedback	χ_π	N	$\mathbb{R}$	1.5	[1.01,1.99]
MP Output Gap feedback	χ_x	N	$\mathbb{R}$	0.5	[0.01,0.99]
MP ToT feedback	χ_τ	N	$\mathbb{R}$	0.5	[-0.49,0.49]
Std. Demand Shock	σ_r	Γ^{-1}	$\mathbb{R}^+$	0.11	[0.038,0.31]
Std. Supply Shock	σ_u	Γ^{-1}	$\mathbb{R}^+$	0.11	[0.038,0.31]
Std. MP Shock	σ_ε	Γ^{-1}	$\mathbb{R}^+$	0.11	[0.038,0.31]
Std. ToT Shock	σ_ϕ	Γ^{-1}	$\mathbb{R}^+$	0.11	[0.038,0.31]
Autoregr. coeff. r_t^N	ρ_r	B	$[0,1]$	0.8	[0.459,0.985]
Autoregr. coeff. u_t	ρ_u	B	$[0,1]$	0.8	[0.459,0.985]
Autoregr. coeff. ϕ_t	ρ_ϕ	B	$[0,1]$	0.8	[0.459,0.985]
Constant Gain	$\overline{\mathbf{g}}$	U	$[0,0.3]$	0.15	[0.008,0.293]

Table 1 - Prior Distributions.
(U= Uniform, N= Normal, Γ= Gamma, B= Beta, Γ^{-1}= Inverse Gamma).

* The priors for $1-n$ for each country i have mean equal to the fraction of foreign equity holdings in the country's portfolio. This equals 0.3027 for Canada, 0.172 for Australia, 0.351 for New Zealand, 0.9381 for Ireland, 0.6114 for Austria, and 0.6201 for the Netherlands (the data are from Sorensen et al., 2007); the standard deviation is equal to 0.2 for all countries, except for Ireland in which it is assumed equal 0.05, to maintain a meaningful shape of the Beta distribution.

		Posterior Means and 95% HPD Intervals					
Description	Parameter	Canada	Australia	New Zealand	Ireland	Austria	Netherlands
Prob. of Leaving the Mkt.	γ^H	0.0197 [0.002,0.052]	0.026 [0.003,0.067]	0.022 [0.002,0.055]	0.022 [0.002,0.05]	0.014 [0.001,0.036]	0.0136 [0.001,0.033]
Openness	$1-n$	0.242 [0.08,0.46]	0.123 [0.03,0.26]	0.326 [0.15,0.55]	0.938 [0.82,0.995]	0.491 [0.18,0.82]	0.504 [0.18,0.86]
Elast. H vs. F Goods	θ	0.76 [0.23,1.28]	0.85 [0.19,1.56]	0.483 [0.12,0.83]	0.544 [0.18,0.93]	0.914 [0.53,1.24]	1.066 [0.91,1.26]
Calvo Price Stick.	α^H	0.92 [0.84,0.99]	0.916 [0.83,0.98]	0.82 [0.70,0.96]	0.942 [0.88,0.99]	0.761 [0.61,0.95]	0.843 [0.74,0.96]
MP Inertia	ρ^H	0.953 [0.92,0.98]	0.941 [0.91,0.97]	0.946 [0.90,0.98]	0.928 [0.86,0.98]	0.97 [0.94,0.99]	0.974 [0.95,0.99]
MP Inflation feedback	χ_π^H	1.314 [0.81,1.83]	1.464 [1.00,1.94]	1.247 [0.7,1.8]	1.419 [0.93,1.91]	1.36 [0.83,1.87]	1.379 [0.88,1.88]
MP Output Gap feedback	χ_x^H	0.362 [0.13,0.60]	0.28 [0.05,0.52]	0.316 [0.09,0.55]	0.181 [−0.04,0.43]	0.32 [0.07,0.57]	0.297 [0.06,1.54]
MP ToT feedback	χ_τ^H	0.147 [−0.17,0.47]	0.204 [−0.03,0.44]	0.005 [−0.29,0.28]	−0.11 [−0.58,0.31]	0.006 [−0.42,0.44]	0.104 [−0.27,0.48]
Std. Demand Shock	σ_r^H	0.64 [0.56,0.74]	0.635 [0.55,0.73]	0.73 [0.62,0.86]	2.22 [1.93,2.56]	0.55 [0.47,0.66]	0.41 [0.35,0.49]
Std. Supply Shock	σ_u^H	0.39 [0.34,0.45]	0.49 [0.43,0.57]	0.84 [0.72,1]	0.46 [0.40,0.54]	1.08 [0.91,1.29]	0.48 [0.41,0.57]
Std. MP Shock	σ_ε^H	0.20 [0.17,0.23]	0.26 [0.23,0.30]	0.22 [0.18,0.25]	0.55 [0.48,0.64]	0.15 [0.12,0.17]	0.10 [0.08,0.12]
Std. ToT Shock	σ_ϕ^H	0.97 [0.85,1.12]	1.44 [1.25,1.66]	1.36 [1.16,1.6]	1.32 [1.14,1.53]	0.9 [0.75,1.06]	1.38 [1.17,1.63]
Autoregr. coeff. r_t^N	ρ_r^H	0.864 [0.77,0.95]	0.89 [0.81,0.97]	0.68 [0.51,0.86]	0.57 [0.42,0.73]	0.69 [0.51,0.88]	0.73 [0.6,0.87]
Autoregr. coeff. u_t	ρ_u^H	0.247 [0.11,0.39]	0.32 [0.18,0.48]	0.18 [0.07,0.33]	0.32 [0.16,0.49]	0.17 [0.06,0.33]	0.13 [0.05,0.26]
Autoregr. coeff. ϕ_t	ρ_ϕ^H	0.609 [0.46,0.76]	0.76 [0.61,0.89]	0.42 [0.23,0.61]	0.66 [0.51,0.8]	0.38 [0.18,0.59]	0.35 [0.18,0.55]
Constant Gain	$\bar{\mathbf{g}}^H$	0.087 [0.077,0.097]	0.091 [0.079,0.103]	0.08 [0.065,0.096]	0.117 [0.1,0.133]	0.102 [0.078,0.123]	0.109 [0.092,0.125]
Wealth Effect	$\frac{\psi}{1+\psi}$	0.0035 [0.0001,0.013]	0.0041 [0.0001,0.015]	0.0039 [0.0001,0.015]	0.0235 [0.0007,0.08]	0.0046 [0.0002,0.016]	0.0049 [0.0002,0.016]

Table 2 - Empirical Results: Posterior Estimates for all countries, Model with Wealth and Expectations effect from foreign stock prices. The Foreign economy in which the main stock market is situated is represented by the U.S. for Canada, Australia, and the Netherlands, by the U.S. and U.K. for Ireland, by the U.S. and Germany for Austria, and by the U.S., Australia, and U.K for New Zealand, and it is treated as an exogenous VAR in the estimation. The numbers in brackets denote 95% Highest Posterior Density (HPD) intervals.

	Log Marginal Likelihoods				
	Model with Learning			**Model with RE**	
	WE & EE	EE, but no WE	WE, but no EE	WE	no WE
Canada	-661.07	**-660.09**	-665.17	-810.50	-806.62
Australia	-740.73	**-740.08**	-750.47	-881.85	-878.21
New Zealand	-578.69	**-577.67**	-586.83	-669.45	-666.52
Ireland	**-830.16**	-832.00	-844.03	-941.57	-942.19
Austria	**-412.05**	-412.35	-418.91	-463.68	-459.76
Netherlands	-429.39	**-427.88**	-514.25	-553.61	-549.78

Table 3 - Bayesian Model Comparison.

Note: WE denotes Wealth Effect, EE denotes Expectations Effect. The log marginal likelihoods are computed using Geweke's modified harmonic mean approximation. Bold face numbers indicate the best-fitting model specification for each country. The models with neither wealth nor expectations effect under learning are not considered in the table, since they are never the preferred model.

	Australia	Canada	New Zealand	Ireland	Austria	Netherlands
Relative MSE	0.853^{***}	0.792^{**}	0.997	0.936	0.865^{*}	0.832^{***}

Table 4 - Estimated economic agents's forecast accuracy. The table reports the relative Mean Squared Error, obtained by dividing the MSE in the case in which agents use the foreign stock price variable to forecast domestic output gap in their Perceived Law of Motion (2.14) by the MSE in the case in which foreign stock prices are not used (i.e., s_t^F does not enter the PLM). Values below 1 imply improvements in forecasting by using foreign stock price information. The table also shows the outcome of Diebold-Mariano tests for forecast accuracy: '***' indicates rejection of the null hypothesis of equal predictive accuracy at the 5% significance level, '**' at the 10% level, and '*' at the 20% level.

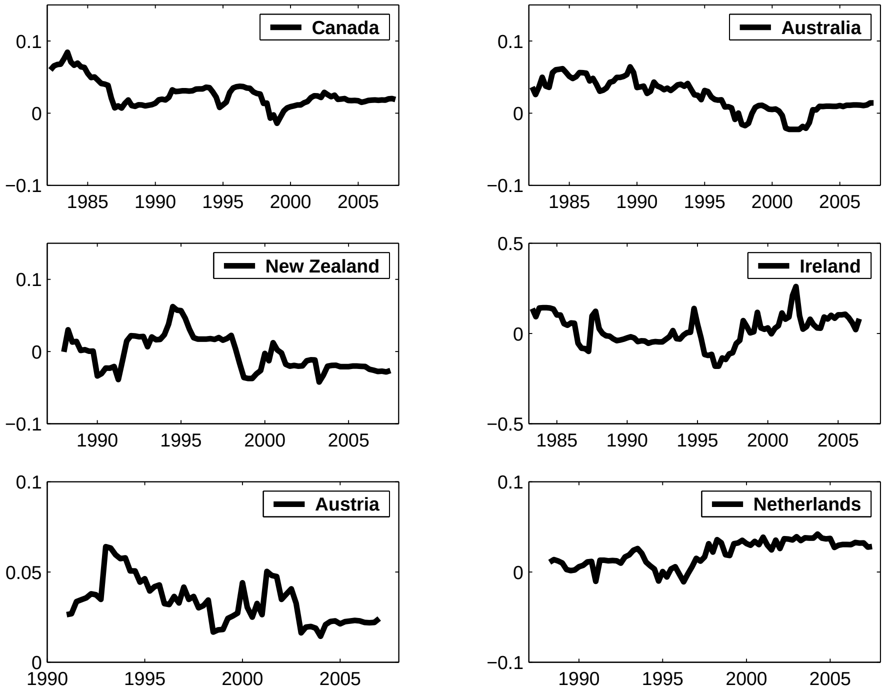

FIGURE 1. Evolving Agents' Beliefs: Perceived Sensitivity of Domestic Output Gap to Foreign Stock Price Gap Movements.

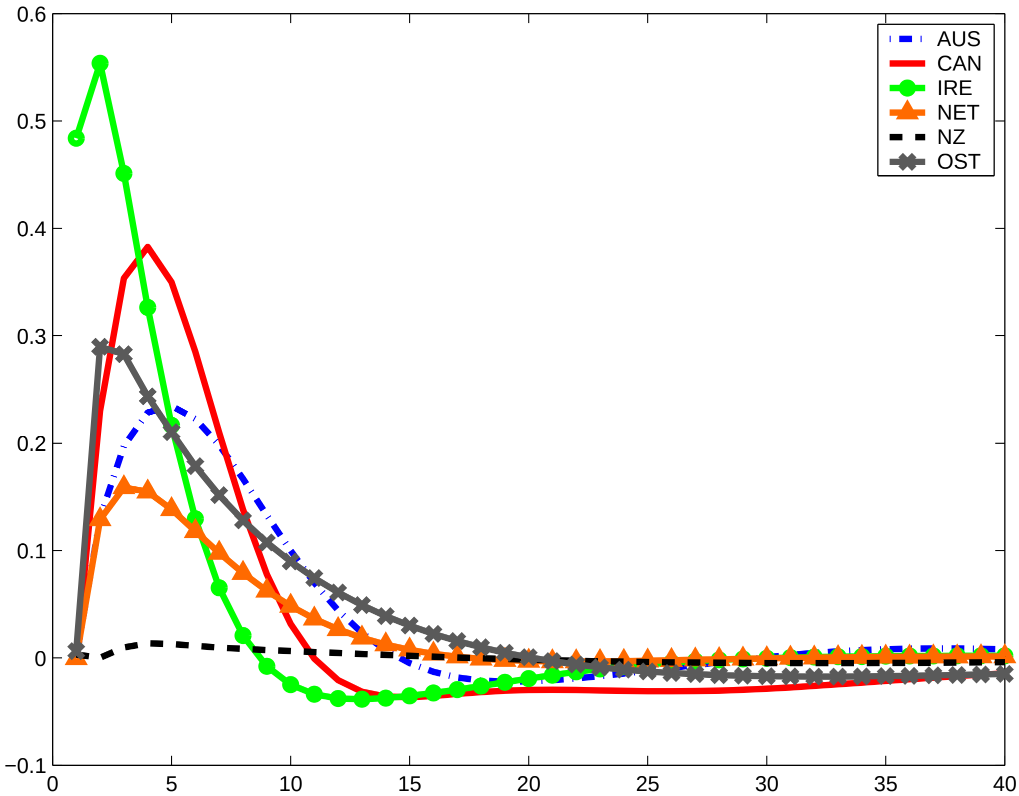

FIGURE 2. Impulse Response Functions of the Output Gap to a one-standard-deviation Foreign Stock Price Gap Shock: Comparison Across Countries.

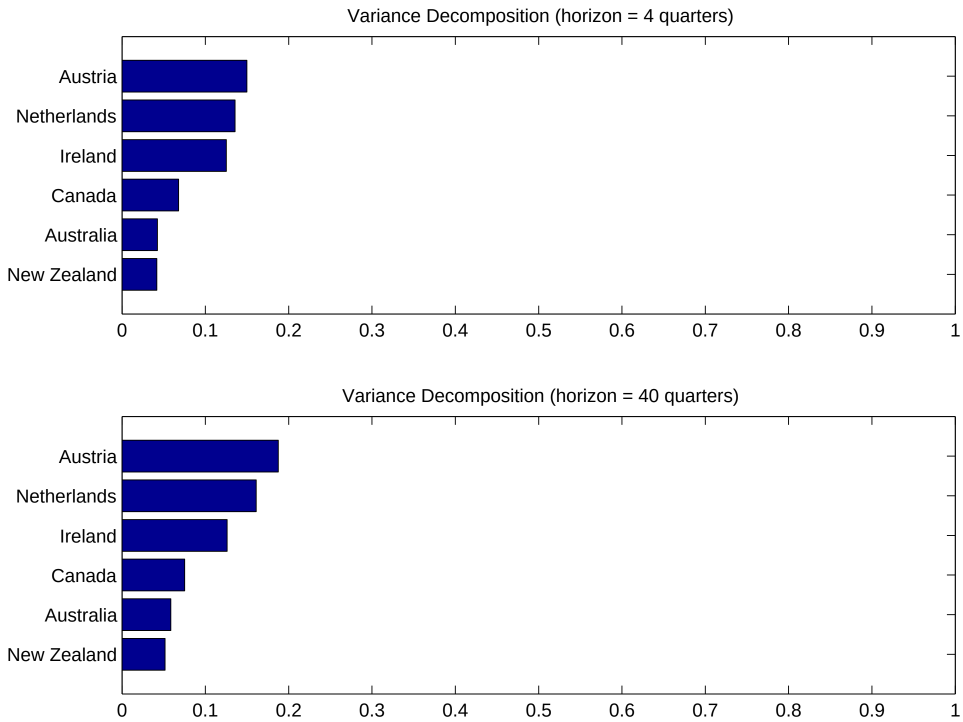

FIGURE 3. Forecast Error Variance Decomposition: Percentage of Output Gap Fluctuations Explained by Foreign Stock Price Gap Shock, across Countries.

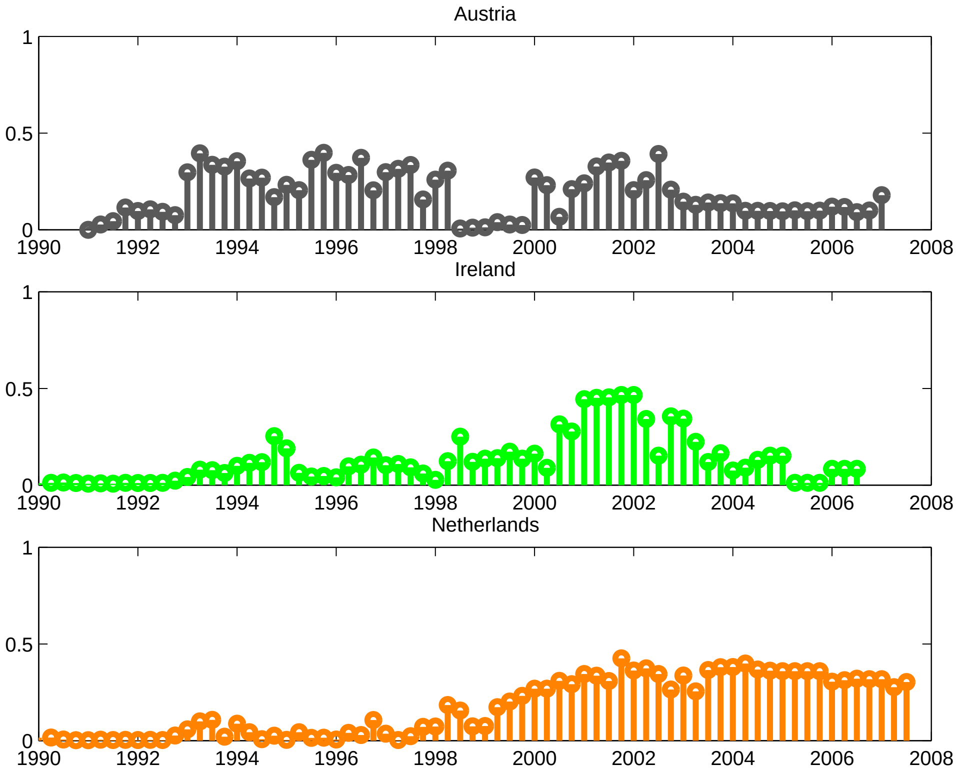

Figure 4. Forecast Error Variance Decomposition: Percentage of Output Gap Fluctuations Explained by Foreign Stock Price Gap Shocks over time (Austria, Ireland, Netherlands).