Cross-Border Equity Investment and the Business Cycle*

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JOB MARKET PAPER

This Version: November 7, 2009

Abstract

I present new evidence that gross foreign assets and liabilities in equity investments, measured at market value, are positively correlated over the business cycle in each of the Group of Seven industrialized countries (G7). The close comovement of assets and liabilities, in turn, reflects strong cross-country correlation between equity prices and moderate comovement of gross outflows and inflows. I analyze an international real business cycle (IRBC) model to evaluate possible causes of these correlations: diminishing marginal product of capital, imperfect substitutability of goods, incomplete markets, and investment project duration. A complete markets model with diminishing returns to capital predicts positive cross-country correlation between equity prices. I show that imperfect substitutability between goods strengthens this correlation, and I show that cross-border financial costs lead to negative correlation between gross capital outflows and inflows. Finally, I develop a model that distinguishes foreign direct investment (FDI) in new projects from portfolio equity. The model suggests that assets and liabilities should be more closely correlated in portfolio equity than in FDI.

JEL Classification: E32, F23, F32, F41

Keywords: Foreign direct investment, portfolio equity, business cycle, international investment position, open economy macroeconomics, DSGE models

*I would like to thank Martin D.D. Evans, Behzad Diba and Dale Henderson for their guidance and encouragement. I am also grateful to Pedro Gete and seminar participants at Georgetown University for helpful comments.

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1 Introduction

This paper explores the relationship between gross foreign assets and liabilities in cross-border equity investments. A country's gross foreign assets will increase if (i) the market value of those assets rises (valuation effect), or (ii) the country buys more foreign assets (capital outflow). I present new evidence that gross equity-based foreign assets and liabilities, measured at market value, are positively correlated over the business cycle in each of the Group of Seven industrialized countries (G7). The close comovement of assets and liabilities, in turn, reflects strong cross-country correlation between equity prices and moderate comovement of gross outflows and inflows. These positive correlations lack an obvious explanation. In particular, it seems more natural to suppose that gross outflows and inflows are negatively correlated. If investors in different countries continually reallocate capital to countries with the highest expected, risk-adjusted returns, then capital should flow more quickly into – and less quickly out of – countries with the best investment prospects. Furthermore, if wealth effects are important, we would expect a "booming" country to buy up existing equity at home and abroad, leading to larger gross outflows and smaller gross inflows.

I analyze an international real business cycle (IRBC) model under several different assumptions to better understand the close correlation between gross foreign assets and liabilities. I consider a number of possible causes: diminishing returns to capital, imperfect substitutability of goods, incomplete markets, and investment project duration. A conventional complete markets IRBC model performs well in explaining the cross-country correlation between equity prices. Diminishing returns to capital is key to this result: it generates capital spillovers in response to a positive productivity shock in one country. If goods are imperfect substitutes, then the terms of trade further amplify the correlation between equity prices by increasing the value of scarce foreign goods after a positive shock to the home country's productivity.

I then introduce capital flow dynamics by restricting the menu of financial assets to equity in home and foreign firms, subject to cross-border financial costs. I calibrate the model's steady-state to match the equity home bias of the U.S. The incomplete markets model predicts that gross outflows and inflows should be *negatively* correlated. Thus the positive outflow/inflow correlations in the data remain a puzzle. The negative correlation in the model reflects a wealth effect: home households own a disproportionately large share of home firms in the calibrated steady-state, so a positive shock to home firms raises home households' relative wealth. These households invest their extra wealth in both home and foreign equity. Because equity claims are in fixed supply, foreign households must sell home equity to home households, causing gross inflows to fall while gross outflows rise.

Aggregate cross-border equity investment consists of foreign direct investment (FDI) and portfolio equity (PE). FDI captures cross-border equity investments that result in a 10% or greater stake in the target company; smaller equity transactions are classified as portfolio equity. FDI, in turn, can be subdivided into mergers and acquisitions (MA) and greenfield investment – the formation of new fixed capital by foreign investors. Greenfield projects typically require a long startup phase before production begins. Examples include the development of new oil fields and the construction of new manufacturing plants. Financial investments in such projects are frequently "locked in" for a period of time before they produce any returns. In contrast, acquisitions can typically be unwound (albeit at a cost), and PE can be withdrawn at any point. Greenfield FDI is therefore likely to be a higher-risk asset class. If so, the business cycle properties of greenfield FDI may differ from those of MA and PE.

I disaggregate gross equity-based capital flows for the G7 and find that PE outflows and inflows are weakly procyclical for most countries, while greenfield FDI outflows and inflows tend to be countercyclical. To explore these differences, I develop an IRBC model of greenfield FDI and PE. I introduce a novel menu of financial assets – claims to long-term and short-term projects in both countries. The model suggests that gross assets and liabilities should be more closely correlated in PE than in FDI. However, the qualitative behavior of the two asset classes is similar. The model predicts procyclical gross outflows and countercyclical gross inflows for both types of equity. The subtle differences in cyclicality observed in the data remain a puzzle.

This paper makes three contributions to the literature. First, on the empirical side, I present new stylized facts about the business cycle behavior of gross foreign assets and liabilities. To my knowledge, all previous business cycle studies of FDI and PE have looked at *flows*; I add an analysis of *positions* at market value and show how they differ from flows.[1] I also examine FDI at a finer granularity by analyzing merger and acquisition flows separately from greenfield FDI flows. Second, I show how different assumptions about preferences and market structure affect the business cycle properties of equity prices, capital flows and foreign asset positions in an IRBC framework. In doing so, I offer new insights into the mechanisms at work in one- and two-good open economy macro models.[2] Third, I develop a model of FDI in new projects and portfolio equity, and I show how the length of the underlying investment project affects the cross-country correlations of equity prices, flows and positions.

The model of FDI and PE contributes to a new but growing literature on the FDI-PE decision. Goldstein and Razin (2005) model a tradeoff between FDI and portfolio equity by introducing an information asymmetry between direct and arms-lengths investors. Albuquerque (2003) develops a small open economy (SOE) model to explain the relative volatilities of FDI and PE inflows to emerging countries. Smith and Valderrama (2009) present an SOE model in which FDI overcomes financial constraints in an emerging country but requires costly search on the part of investors. My

[1] Recent business cycle studies of disaggregated capital flows include Contessi et al. (2009) and Smith and Valderrama (2009). See also Albuquerque (2003) and references therein. Lane and Milesi-Ferretti (2007), Gourinchas and Rey (2007), Tille and Van Wincoop (2007) and Devereux and Sutherland (2008) emphasize the importance of valuation effects in understanding foreign assets positions. However, they do not investigate the business cycle properties of these positions.

[2] Important examples of such models include (but are not limited to) Backus et al. (1992), Baxter and Crucini (1995), Stockman and Tesar (1995), Baxter and Jermann (1997), Heathcote and Perri (2002), and Heathcote and Perri (2008).

main contribution here is to explicitly model *two-way* FDI and portfolio equity investment between similar countries, rather than one-way flows into an emerging country.

The rest of the paper proceeds as follows. Section 2 presents stylized business cycle facts for cross-border equity investment in the G7. Section 3 presents the benchmark IRBC model and analyzes its predictions for equity prices, capital flows and foreign asset positions under several different assumptions about preferences and market structure. Section 4 develops a model of FDI and PE and analyzes its predictions for equity prices, flows and positions in each asset class. Section 5 offers some concluding remarks. A technical Appendix provides additional details on the data and models.

2 Cross-border equity investment in the G7: Business cycle facts

This section documents the business cycle properties of equity-based gross foreign assets and liabilities in the G7 countries. I use a data set from Lane and Milesi-Ferretti (2007) that includes gross FDI and portfolio equity (PE) assets and liabilities at annual frequency for a large sample of countries from 1980 – 2004. An advantage of this data is that it measures positions at *market value*. The authors thus account for valuation effects as well as capital flows when constructing positions. Consider gross foreign assets for a given "home" country. Let P_t be a price index for foreign assets at the end of period t, and let A_t be a quantity index of assets held (e.g., number of equity shares) at the end of period t. The change in gross foreign assets can be decomposed as follows:

$$\begin{aligned}\Delta\text{Gross foreign assets}_t &= P_tA_t - P_{t-1}A_{t-1}\\ &= P_t(A_t - A_{t-1}) + A_{t-1}(P_t - P_{t-1})\\ &= \text{Capital outflows} + \text{Valuation effect}\end{aligned}$$

The first term captures the home country's net new purchases of foreign assets.[3] The second term captures the change in value of the country's prior holdings. Valuation effects in turn arise from two sources: changes in foreign asset prices and changes in exchange rates. Lane and Milesi-Ferretti (2007) show that valuation changes can have large effects on the market value of gross foreign assets and liabilities.

Table 1 (left side) presents business cycle correlations between gross foreign assets and liabilities based on the Lane and Milesi-Ferretti (2007) data set. The first column gives the correlations between total equity-based assets (FDI plus portfolio equity) and liabilities. The correlations are

[3]For illustration, I have assumed that all purchases and sales of assets in period t take place at the end-of-period price P_t. A similar decomposition can be made when transactions take place at varying prices over the period; see Lane and Milesi-Ferretti (2007) for details.

	eqa, eql	fda, fdl	pea, pel	eqo, eqi	fdo, fdi	peo, pei
U.S.	0.89*	0.87*	0.91*	0.64*	0.68*	0.27
U.K.	0.84*	0.31	0.84*	0.87*	0.86*	0.09
France	0.82*	0.57*	0.85*	0.86*	0.18	0.68*
Germany	0.86*	0.59*	0.73*	0.39	-0.12	-0.51*
Japan	0.50*	-0.55*	0.86*	-0.22	-0.30	-0.21
Canada	0.82*	0.71*	0.84*	0.82*	0.61*	0.57*
Italy	0.58*	0.69*	0.38	-0.04	0.26	-0.18

Table 1: **Business cycle correlations between gross equity-based foreign assets and liabilities: G7 countries, 1980 – 2004.** eqa is the stock of real gross FDI plus portfolio equity (PE) assets at market value, eql is the stock of real gross FDI plus PE liabilities at market value, fda is the stock of real gross FDI assets at market value, fdl is the stock of real gross FDI liabilities at market value, pea is the stock of real gross PE assets at market value, pel is the stock of real gross PE liabilities at market value, eqo is real gross equity outflows, eqi is real gross equity inflows, fdo is real gross FDI outflows, fdi is real gross FDI inflows, peo is real gross PE outflows, and pei is real gross PE inflows. See the Appendix for details. Stars denote significance at the 5% level of a two-sided t-test of the null hypothesis that the correlation coefficient is zero.

positive and significant for all seven countries.[4] The second column presents correlations between gross FDI assets and liabilities, and the third column presents correlations between gross portfolio equity assets and liabilities. Here FDI captures all cross-border equity investments that result in a 10% or greater stake in the target company. For FDI, gross assets and liabilities are positively correlated for six of the G7 countries, and five of the correlations are significant. (Japan is a notable exception.) For portfolio equity, all seven countries have positive correlations, and six are significant. Overall, gross equity-based assets and liabilities are closely correlated for most of the G7.

Are gross outflows and inflows positively correlated as well? I examine data on capital flows from the IMF's International Financial Statistics (for portfolio equity) and UNCTAD's World Investment Report (for FDI). The fourth column of Table 1 gives the correlation between total equity outflows (FDI plus portfolio equity) and inflows. For three countries (U.K., France and Canada), the outflow/inflow correlation is about the same as the asset/liability correlation. For the other countries, outflows and inflows are less closely correlated. A similar pattern holds for FDI and portfolio equity separately (fifth and sixth columns).

The fact that assets and liabilities are more closely correlated than outflows and inflows suggests that valuation effects are very closely correlated. To confirm this, I construct time series for valuation effects using the data on positions from Lane and Milesi-Ferretti (2007) together with

[4]The original data is in current U.S. dollars. I convert the nominal series to constant 2000 U.S. dollars using a world GDP deflator. I then remove a nonlinear trend using a Hodrick-Prescott filter with a smoothing parameter of 6.25, which Ravn and Uhlig (2002) suggest for annual data. Results using alternative filters (Baxter-King band-pass, Christiano-Fitzgerald random walk, time trend) are similar and available on request. "Significance" refers to a two-sided t-test of the null hypothesis that the correlation coefficient is zero. See the Appendix for details.

	$eqav, eqlv$	$fdav, fdlv$	$peav, pelv$
U.S.	0.94*	0.92*	0.92*
U.K.	0.76*	0.26	0.83*
France	0.79*	0.71*	0.92*
Germany	0.90*	0.46*	0.94*
Japan	0.44*	-0.77*	0.70*
Canada	0.93*	0.81*	0.82*
Italy	0.81*	0.76*	0.73*

Table 2: **Business cycle correlations between equity-based asset and liability valuation effects: G7 countries, 1980 – 2004.** *eqav* is the real capital gain on gross FDI plus portfolio equity (PE) assets, *eqlv* is the real capital gain on gross FDI plus PE liabilities, $fdav$ is the real capital gain on gross FDI assets, $fdlv$ is the real capital gain on gross FDI liabilities, *peav* is the real capital gain on gross PE assets, and *pelv* is the real capital gain on gross PE liabilities. See the Appendix for details. Stars denote significance at the 5% level of a two-sided t-test of the null hypothesis that the correlation coefficient is zero.

the data on flows from the IMF and UNCTAD.[5] Table 2 gives the correlations between asset and liability valuation effects for total equity as well as for FDI and portfolio equity separately. The correlations are large and significant for most countries. This suggests that equity prices (measured in a common currency) co-move strongly over the business cycle: when the price of foreign equity is high, the price of home equity tends to be high as well. Assets and liabilities therefore co-move more strongly than outflows and inflows.

Do gross foreign assets and liabilities co-move positively or negatively with the home country's real GDP? Table 3 presents business cycle correlations between total equity positions and domestic output (left side) and between total equity flows and domestic output (right side). Gross equity-based assets and liabilities are weakly procyclical for most countries. The positive correlations with GDP are especially strong in the U.S., and they are weakest or absent for Japan and Italy. Equity outflows and inflows are also generally procyclical.

The analysis so far has treated FDI as a single type of investment. However, FDI consists of two conceptually distinct components: mergers and acquisitions (MA) and greenfield investment. A merger or acquisition involves an investor in one country acquiring a lasting interest in an existing foreign firm.[6] In contrast, greenfield FDI describes an investor in one country starting a new firm in a foreign country. Do MA and greenfield FDI behave similarly over the business cycle? To address this question, I use detailed FDI data from UNCTAD's World Investment Report from 1987 – 2004. For this time horizon, UNCTAD measures both total FDI outflows and inflows as well

[5] Consider FDI assets as an example. For each year, I compute the change in FDI assets at market value from the end of the prior year to the end of the current year. I then subtract gross FDI outflows that took place during the year. The residual is the valuation effect: the capital gain or loss on the prior year's FDI assets. See the Appendix for details.

[6] A "lasting interest" is typically defined as ownership of 10% or more of a firm's outstanding equity. See the Appendix for details.

	eqa, y	eql, y	eqo, y	eqi, y
U.S.	0.55*	0.51*	0.45*	0.62*
U.K.	0.25	0.25	0.28	0.19
France	0.20	0.12	0.49*	0.38
Germany	0.31	0.16	0.20	0.32
Japan	0.06	-0.22	0.01	-0.03
Canada	0.34	0.36	0.29	0.35
Italy	0.02	-0.14	0.03	0.19

Table 3: **Business cycle correlations of equity-based positions and flows with domestic output: G7 countries, 1980 – 2004.** *eqa* is the stock of real gross FDI plus portfolio equity (PE) assets at market value, *eql* is the stock of real gross FDI plus PE liabilities at market value, *eqo* is real gross equity outflows, *eqi* is real gross equity inflows, and *y* is real GDP. See the Appendix for details. Stars denote significance at the 5% level of a two-sided *t*-test of the null hypothesis that the correlation coefficient is zero.

	mao, mai	gro, gri
U.S.	0.86*	0.79*
U.K.	0.92*	0.61*
France	0.60*	0.38
Germany	-0.10	-0.02
Japan	0.47*	0.00
Canada	0.61*	0.49*
Italy	0.22	0.70*

Table 4: **Business cycle correlations between gross outflows and inflows in mergers and acquisitions (MA) and greenfield FDI: G7 countries, 1987 – 2004.** *mao* is real gross MA outflows, *mai* is real gross MA inflows, *gro* is real gross greenfield FDI outflows and *gri* is real gross greenfield FDI inflows. See the Appendix for details. Stars denote significance at the 5% level of a two-sided *t*-test of the null hypothesis that the correlation coefficient is zero.

as MA outflows and inflows. Following Calderón et al. (2004), I obtain a rough proxy for greenfield flows by subtracting MA from total flows.[7]

Table 4 presents business cycle correlations between MA outflows and inflows (left column) and between greenfield FDI outflows and inflows (right column). (Data on MA and greenfield FDI positions at market value is not available.) Most of the outflow/inflow correlations are positive for both types of FDI. The positive correlations are especially strong in the U.S., U.K. and Canada; they are weaker or absent in Germany and Japan. Overall, outflows and inflows do co-move in both categories for most of the G7.

Table 5 presents business cycle correlations between MA flows and output, between greenfield

[7] The proxy for greenfield flows is imperfect because total FDI flows include a third component: financial transactions between parents and foreign subsidiaries. Some, but not all, of these transactions reflect new capital investment in the foreign country. Despite the limitations, this approach provides a useful first pass at separating greenfield FDI from mergers and acquisitions.

	mao, y	mai, y	gro, y	gri, y	peo, y	pei, y
U.S.	0.73*	0.83*	0.08	0.16	0.17	0.40*
U.K.	0.26	0.39	-0.25	-0.32	0.22	0.10
France	0.58*	0.21	-0.16	0.16	0.04	0.21
Germany	0.20	0.37	-0.31	-0.40	0.26	-0.10
Japan	0.41	-0.10	0.24	-0.06	-0.30	-0.02
Canada	0.30	0.53*	-0.22	-0.34	0.23	0.11
Italy	0.28	0.03	0.15	0.21	-0.06	0.05

Table 5: **Business cycle correlations between disaggregated gross capital flows and output: G7 countries, 1987 – 2004.** *mao* is real gross merger and acquisition (MA) outflows, *mai* is real gross MA inflows, *gro* is real gross greenfield FDI outflows, *gri* is real gross greenfield FDI inflows, *peo* is real gross PE outflows, *pei* is real gross PE inflows, and y is real GDP. See the Appendix for details. Stars denote significance at the 5% level of a two-sided t-test of the null hypothesis that the correlation coefficient is zero.

FDI flows and output, and between PE flows and output. MA outflows and inflows are both procyclical for most of the G7; the only exception is MA inflows for Japan. The pattern is less clear-cut for the other types of equity. Greenfield FDI outflows and inflows are each weakly countercyclical for four out of seven countries, while PE flows are weakly procyclical for a majority of countries. Overall, MA is the most procyclical type of equity, and greenfield FDI is the most likely to be countercylical. Studies that focus on aggregate FDI flows will likely miss this subtle distinction.

To summarize the main findings from this section:

1. Gross equity-based assets and liabilities are closely correlated in most of the G7 countries.

2. The correlations between asset and liability valuation effects are generally stronger than the correlations between gross capital outflows and inflows.

3. Total gross positions and flows are procyclical for most of the G7. Merger and acquisition (MA) flows are the most procyclical, while greenfield FDI flows are weakly countercyclical for a majority of countries.

4. Gross MA outflows and inflows are positively correlated in most of the G7, as are gross greenfield FDI outflows and inflows.

3 Benchmark model

What economic channels can account for the close correlation between gross equity-based foreign assets and liabilities in the G7? The preceding analysis reveals two proximate causes. First, valuation effects are closely correlated across countries. Second, gross outflows and inflows are positively correlated in many countries. For most of the G7, the correlation between home and foreign valuation effects is stronger than the correlation between outflows and inflows.

To think about underlying causes, we need a model. An international real business cycle (IRBC) framework is a natural starting point, as it has been shown to be broadly consistent with a large set of international business cycle facts (Backus et al. (1992), Heathcote and Perri (2008)). I analyze an IRBC model under several different assumptions about preferences and market structure. The next section lays out the benchmark model.

3.1 Model

The model features two countries and two traded goods. Perfectly competitive firms in each country produce country-specific output goods using country-specific physical capital. The production function has diminishing returns to capital. Production is also subject to country-specific aggregate productivity shocks each period. These shocks are the only sources of uncertainty in the model. Each period, firms choose how to allocate their output between dividends to shareholders and new investment. Households in each country like to consume bundles of home and foreign output goods, with a possible bias toward domestic goods. Households also trade equity shares in home and foreign firms. An equity share entitles its owner to a fraction of the firm's dividend for as long as the household owns the share.

3.1.1 Households

Each country is populated with a continuum of identical households. Households in the home country have the following preferences:

$$E_t \left[\sum_{j=0}^{\infty} \beta^j \frac{C_{t+j}^{1-\gamma}}{1-\gamma} \right] \tag{1}$$

where $\beta \in (0,1)$ is the subjective discount factor and $\gamma > 0$ is the constant coefficient of relative risk aversion. C_t denotes home households' consumption of home consumption goods, which are a CES aggregate of home and foreign output goods:

$$C_t = \left[\lambda^{\frac{1}{\phi}} \left(C_t^H \right)^{\frac{\phi-1}{\phi}} + (1-\lambda)^{\frac{1}{\phi}} \left(C_t^F \right)^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}} \tag{2}$$

Here C_t^H and C_t^F denote the home household's consumption of home and foreign output goods, $\lambda \in (0,1)$ is the weight that home households assign to home output goods, and $\phi > 0$ is the elasticity of substitution between home and foreign output goods. Let P_t^H and P_t^F denote the prices of home and foreign output goods in terms of a numeraire (to be defined shortly). Then the numeraire price indices of home and foreign consumption goods, denoted P_t and $\widehat{P}_t$, are as follows:

$$P_t = \left[\lambda \left(P_t^H\right)^{1-\phi} + (1-\lambda)\left(P_t^F\right)^{1-\phi}\right]^{\frac{1}{1-\phi}} \tag{3}$$

$$\widehat{P}_t = \left[(1-\lambda)\left(P_t^H\right)^{1-\phi} + \lambda \left(P_t^F\right)^{1-\phi}\right]^{\frac{1}{1-\phi}} \tag{4}$$

I take the numeraire to be the geometric mean of the home and foreign consumption price indices:[8]

$$P_t^{\frac{1}{2}} \widehat{P}_t^{\frac{1}{2}} = 1 \tag{5}$$

Recall that a household can hold equity shares in home and foreign firms. I assume that it is costly for home (foreign) households to deviate from their long-run holdings of foreign (home) equity. The home household's budget constraint is:

$$\begin{aligned} P_t C_t + P_t^{X,H} A_t^H + P_t^{X,F} A_t^F = \\ (P_t^{X,H} + D_t^H) A_{t-1}^H + (P_t^{X,F} + D_t^F) A_{t-1}^F - \frac{\psi}{2} P_t^F \left(A_t^F - A^F\right)^2 \end{aligned} \tag{6}$$

where A_t^H and A_t^F are the number of shares of home and foreign equity held by the home household at the end of period t; D_t^H and D_t^F are the total dividends paid by home and foreign firms, measured in units of the numeraire; $P_t^{X,H}$ and $P_t^{X,F}$ are the numeraire prices of home and foreign equity; and A^F is the long-run number of foreign equity shares held by the home household (i.e., the steady-state value of A_t^F). The parameter ψ controls the magnitude of the cross-border financial cost, which is paid in units of foreign output goods. The household's problem is to maximize (1) subject to (2) and (6), taking all prices as given.

The foreign household faces a mirror-symmetric problem; the Appendix gives details. The first-order conditions for home and foreign households' equity holdings are:

[8] This choice of numeraire is convenient for exposition, as it imposes symmetry. However, the choice of numeraire does not affect the results.

$$1 = E_t \left[M_{t+1,t} R^{X,H}_{t+1} \right] \tag{7}$$

$$1 = E_t \left[M_{t+1,t} R^{*X,F}_{t+1} \right] \tag{8}$$

$$1 = E_t \left[\widehat{M}_{t+1,t} R^{*X,H}_{t+1} \right] \tag{9}$$

$$1 = E_t \left[\widehat{M}_{t+1,t} R^{X,F}_{t+1} \right] \tag{10}$$

$$\text{where } M_{t+1,t} \equiv \frac{\beta C^{-\gamma}_{t+1} P^{-1}_{t+1}}{C^{-\gamma}_t P^{-1}_t} \tag{11}$$

$$\text{and } \widehat{M}_{t+1,t} \equiv \frac{\beta \widehat{C}^{-\gamma}_{t+1} \widehat{P}^{-1}_{t+1}}{\widehat{C}^{-\gamma}_t \widehat{P}^{-1}_t} \tag{12}$$

$M_{t+1,t}$ is the home household's intertemporal marginal rate of substitution (IMRS) of time-$(t+1)$ numeraire goods for time-t numeraire goods, and $\widehat{M}_{t+1,t}$ is the foreign household's IMRS. The equity returns are given by:

$$R^{X,H}_{t+1} \equiv \frac{P^{X,H}_{t+1} + D^{X,H}_{t+1}}{P^{X,H}_t} \tag{13}$$

$$R^{*X,F}_{t+1} \equiv \frac{P^{X,F}_{t+1} + D^{F}_{t+1}}{P^{X,F}_t + \psi P^F_t \left(A^F_t - A^F \right)} \tag{14}$$

$$R^{*X,H}_{t+1} \equiv \frac{P^{X,H}_{t+1} + D^{H}_{t+1}}{P^{X,H}_t + \psi P^H_t \left(\widehat{A}^H_t - \widehat{A}^H \right)} \tag{15}$$

$$R^{X,F}_{t+1} \equiv \frac{P^{X,F}_{t+1} + D^{F}_{t+1}}{P^{X,F}_t} \tag{16}$$

Here $\widehat{A}^H_t$ is the number of shares of home equity held by the foreign household at the end of period t, and $\widehat{A}^H$ is the long-run (steady-state) value of $\widehat{A}^H_t$. $R^{*X,F}_{t+1}$ and $R^{*X,H}_{t+1}$ are the *effective* returns on foreign and home equity to home and foreign households, respectively. Note that when the home household holds more than the steady-state level of foreign equity, an additional purchase of foreign equity increases cross-border costs, depressing the effective return $R^{*X,F}_{t+1}$. Conversely, when the home household holds less than the steady-state level of foreign equity, an additional purchase of foreign equity decreases cross-border costs (by bringing the position closer to the steady-state), enhancing the effective return. Analogous reasoning applies to foreign holdings of home equity.

3.1.2 Firms

Each country is populated with a continuum of perfectly competitive firms that produce country-specific output goods using country-specific physical capital. The production function for home firms is:

$$Y_t^H = Z_t^H \left(K_{t-1}^H\right)^\theta \ , 0 < \theta < 1 \tag{17}$$

Here K_{t-1}^H is the home firm's capital stock at the end of period $t-1$, available for production in period t; Y_t^H is the output produced by the home firm; and Z_t^H is an aggregate productivity shock affecting all firms operating in the home country. Firms choose capital levels and dividends each period to maximize the expected present discounted value of dividends to shareholders, discounted using the domestic household's IMRS. Formally, home firms solve the following problem:

$$\max_{K_t^H, D_t^H} D_t^H + \sum_{j=1}^{\infty} M_{t+j,t} D_{t+j}^H$$
$$\text{s.t. } D_t^H = P_t^H \left[Y_t^H + (1-\delta)K_{t-1}^H - K_t^H\right] \tag{18}$$

D_t^H denotes total dividends paid by home firms to their shareholders, measured in units of the numeraire; $M_{t+j,t}$ is the home household's intertemporal marginal rate of substitution (IMRS) of time-$(t+j)$ numeraire goods for time-t numeraire goods; and $\delta \in [0,1]$ is the depreciation rate. Note that K_t^H and Y_t^H are measured in units of home output goods. The implicit assumption is that home output goods can be converted one-for-one to home investment goods (and vice versa).[9] The home firm's first-order condition is:

$$1 = E_t \left[M_{t+1,t} \frac{P_{t+1}^H}{P_t^H} \left(\frac{\theta Y_{t+1}^H}{K_t^H} + 1 - \delta \right) \right] \tag{19}$$

Comparing this equation to the household's first-order condition for home equity (7), we see that the expected risk-adjusted return to physical capital in home firms must equal the expected risk-adjusted return to home equity for home households.

3.1.3 Market clearing

Market clearing for output goods requires:

[9] It would be straightforward to relax this assumption, either by introducing capital adjustment costs or by requiring that investment goods be composites of home and foreign output goods.

$$K_t^H - (1-\delta)K_{t-1}^H + C_t^H + \widehat{C}_t^H = Y_t^H - \frac{\psi}{2}\left(\widehat{A}_t^H - \widehat{A}^H\right)^2 \tag{20}$$

$$K_t^F - (1-\delta)K_{t-1}^F + C_t^F + \widehat{C}_t^F = Y_t^F - \frac{\psi}{2}\left(A_t^F - A^F\right)^2 \tag{21}$$

I model the financial costs as "iceberg" costs; that is, no agent derives any benefit from them. I normalize the supply of equity shares in home and foreign firms to one:

$$1 = A_t^H + \widehat{A}_t^H \tag{22}$$

$$1 = A_t^F + \widehat{A}_t^F \tag{23}$$

Note that with this normalization, we can interpret A_t^F as the share of outstanding foreign equity held by home households and $\widehat{A}_t^H$ as the share of outstanding home equity held by foreign households. I will refer to A_t^F and $\widehat{A}_t^H$ as the *cross-border ownership shares.*

3.1.4 Shock processes

The shock vector s_t for this economy is the pair of log productivity shocks $(\ln Z_t^H, \ln Z_t^F)'$. I close the model by specifying a stochastic process for the shock vector:

$$s_t = \rho s_{t-1} + \epsilon_t \ , \ 0 \leq \rho < 1 \tag{24}$$

where $\epsilon_t \equiv (\epsilon_t^H, \epsilon_t^F)'$ is a vector of mean-zero iid innovations with variance-covariance matrix Σ:

$$\Sigma \equiv \begin{bmatrix} \sigma_H^2 & \xi\sigma_H\sigma_F \\ \xi\sigma_H\sigma_F & \sigma_F^2 \end{bmatrix} \tag{25}$$

3.1.5 Equilibrium

A competitive equilibrium is a sequence of prices and allocations such that all markets clear when consumers and firms behave optimally, taking equilibrium prices as given. The Appendix gives more details on the foreign household's problem, first-order conditions, and the solution method.

3.2 A complete markets version with one good

I start by analyzing a frictionless, complete markets version of the benchmark model with one good. I calibrate the model with the U.S. as the home country and the "rest of the world" (ROW) as the foreign country. Assume (for now) that in addition to trading equities, households in both countries can trade a complete set of state-contingent claims. It is then straightforward to show that:

$$M_{t+1,t} = \widehat{M}_{t+1,t} \tag{26}$$

This is the Backus-Smith condition: with complete markets, the IMRS of home and foreign households must equalize in all dates and states. For this exercise, I also set $\psi = 0$, so there are no financial frictions associated with equities. To make the two good model effectively have one good, I set the elasticity of substitution between home and foreign output goods, ϕ, arbitrarily high; and I set the weight of home (foreign) output goods in the home (foreign) consumption bundle, λ, to one-half.[10]

The remaining parameters are calibrated as follows. I set the annual subjective discount factor β to 0.95, corresponding to a steady-state real interest rate of about 5%. The coefficient of relative risk aversion γ is set to 2, a common value in the literature. I set the production function parameter θ to 0.3 and the depreciation rate δ to 0.08.[11] I set ρ to 0.8, and I calibrate σ_H and σ_F to 0.0087 to match the standard deviation of U.S. output. (The standard deviation of global output is similar.) I set the correlation coefficient between home and foreign technology shocks ξ to zero in order to demonstrate the model's ability to generate positive correlation between equity prices without forcing the two countries' output processes to move together. Note that with $\psi = 0$, the parameters A^F and $\widehat{A}^H$ do not enter any of the model's equations and therefore do not need to be calibrated.

Figure 1 (dashed lines) presents impulse responses of capital stocks, dividends and equity prices to a one standard deviation shock to home country technology. In response to the shock, the capital stock of home firms rises on impact, while the capital stock of foreign firms falls. With complete markets, we can interpret the results in terms of a social planner who maximizes the joint welfare of home and foreign households. The social planner invests physical capital so as to equalize the expected marginal products of capital (MPK) across the two countries. With diminishing returns to capital, equalization of expected MPKs requires an increase in the capital stock of home firms following a positive shock to home technology. For this calibration, the planner must also decrease the capital stock of foreign firms on impact – effectively transferring capital from foreign to home firms. Starting tomorrow, if there are no more shocks, expected technology in home firms will decay relative to foreign firms, and the planner will gradually transfer capital back from home to foreign firms. Eventually, the foreign capital stock rises above its steady-state level. Because the foreign capital stock drops on impact, foreign dividends also fall tomorrow and stay low for several periods. However, foreign dividends also eventually rise above their steady-state level. Whether the price

[10] Alternatively, one can rewrite the model explicitly in terms of one good. I have verified that the two approaches give exactly the same results.

[11] There is no labor in the model. However, if I added labor to the production function in a Cobb-Douglas way, θ would be the share of capital in income.

of a foreign firm goes up or down on impact depends on the relative strength of the initial decline in dividends versus the eventual rise. It also depends on the discount factor. For the calibrated model, the foreign equity price rises on impact, and equity prices are positively correlated across countries. The correlation coefficient (0.89) is quite high.

3.3 A complete markets version with two goods

Next I analyze a complete markets version of the model in which output goods are imperfect substitutes. For this calibration, I set the elasticity of substitution between home and foreign output goods, ϕ, to 2. Estimates of ϕ vary widely. However, Coeurdacier (2009) argues that this elasticity should be greater than unity; otherwise, a model with internationally traded equities would suffer immiserizing growth. I set the weight of home (foreign) output goods in the home (foreign) consumption bundle, λ, to 0.75, for a steady-state import share of 25%. The remaining parameters are calibrated as in the one good complete markets model (Section 3.2).

Figure 1 (solid lines) presents impulse responses of capital stocks, dividends and equity prices to a one standard deviation shock to home country technology in the two good model. In contrast with the one good model (dashed lines), capital in foreign firms does not fall on impact. Recall that home and foreign capital stocks are measured in terms of home and foreign output goods, while dividends and equity prices are measured in terms of the numeraire. The social planner now seeks to equalize expected marginal products of capital (MPK) *in terms of the numeraire*. The planner's optimal capital allocation thus depends not only on expected technology and capital levels but also on relative goods prices. The home technology shock causes a boom in home output goods, which raises the relative price of foreign output goods. The terms of trade – the price of home output goods divided by the price of foreign output goods – fall, as shown in the bottom-most impulse response.[12] Since the shock is persistent, the excess of home goods is expected to persist, and the terms of trade are expected to remain below their steady-state level. This raises the expected numeraire-based MPK of foreign firms relative to the one good case, prompting the planner to allocate more capital to foreign firms on impact.

Dividends paid by foreign firms increase on impact because of the rise in the price of foreign goods. Foreign dividends stay high, both because the foreign goods price stays high and because the planner invests more capital in foreign firms over time. Home capital and dividends rise on impact and stay high as a direct result of the technology shock. Since home and foreign dividends rise on impact and remain high, both equity prices also rise on impact. For this calibration, equity prices are even more closely correlated across countries (0.99) than in the one good complete markets model (0.89).

[12] In the one good model, the terms of trade are constant, because both countries produce identical goods.

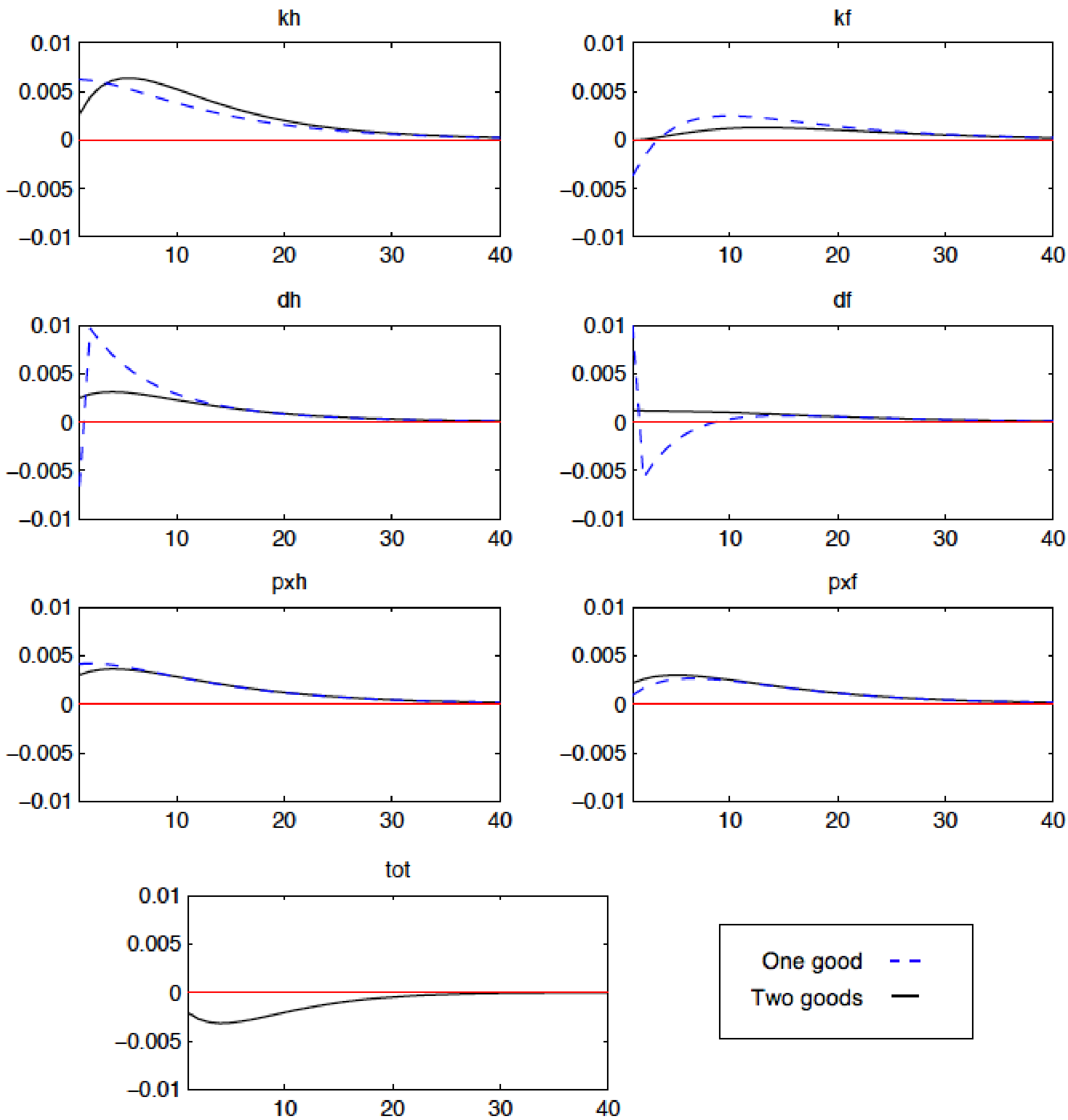

Figure 1: **Impulse responses to a one standard deviation shock to home country technology: complete markets models.** The dashed lines are impulse responses in the one good complete markets version, and the solid lines are responses in the two good complete markets version. kh is the capital stock of home firms, kf is the capital stock of foreign firms, dh is dividends paid by home firms, df is dividends paid by foreign firms, pxh is the price of an equity share in home firms, pxf is the price of an equity share in foreign firms, and tot is the terms of trade (the price of home output goods divided by the price of foreign output goods – two good model only).

3.4 Benchmark model with financial costs and two goods

The complete markets model demonstrates that equity prices can be very closely correlated across countries when capital is allocated so as to ensure perfect risk-sharing. However, the complete markets model is less informative about asset ownership. As long as households can trade a complete set of state-contingent claims, the cross-border equity ownership shares are indeterminate. One approach is to prohibit households from trading state-contingent claims, but keep trade in equities frictionless ($\psi = 0$). It is then possible to solve for cross-border ownership shares in the "near-nonstochastic steady-state" using the method of Devereux and Sutherland (2008).[13] However, the steady-state ownership shares predicted by the frictionless model imply much more diversification than we see in the data. This is the well known "equity home bias" puzzle. For example, the calibrated two good model predicts that foreigners will own 70% of home equity in the steady-state. This vastly overstates the average foreign ownership share of U.S. equity from 1980 to 2004, which was about 7%.

My goal is not to solve the equity home bias puzzle; rather, I want to analyze how equity holdings respond to shocks when average holdings resemble what we see in the data. To accomplish this, I "turn on" the cross-border financial costs by setting $\psi > 0$. Recall that this imposes a small cost on home (foreign) households to being away from their long-run holdings of foreign (home) equity. The key is that the steady-state cross-border ownership shares are calibrated to reflect the "underdiversification" observed in the real world, rather than the values that complete markets. This approach generates first-order dynamics in ownership shares around a unique, locally stationary steady-state.

There are three new parameters to be calibrated: the steady-state share of U.S. equity held by foreigners ($\widehat{A}^H$), the steady-state share of foreign equity held by the U.S. (A^F), and the cross-border cost parameter ψ. To get a sense of $\widehat{A}^H$, I use data on U.S. equities outstanding from the Federal Reserve Flow of Funds. For each year (1980 – 2004), I compute the ratio of U.S. portfolio equity liabilities (from Lane and Milesi-Ferretti (2007)) to U.S. equities outstanding. The average value of this ratio is 0.07. To get a sense of A^F, I use data from the World Federation of Exchanges (WFE) to compute annual ratios of U.S. portfolio equity assets to foreign equities outstanding (1990 – 2004).[14] The average value is 0.09. To keep the model symmetric, I set $\widehat{A}^H = A^F = 0.08$. That is, 8% of each country's equity is held by the other country's households in the steady-state.[15]

Recall that the parameter ψ controls the magnitude of the cross-border financial costs. I follow Schmitt-Grohé and Uribe (2003) and calibrate ψ to match the standard deviation of the U.S. current-account-to-GDP ratio (0.011). The calibrated value for ψ is 12. I report results for the two

[13] For the symmetric model presented here, the steady-state cross-border ownership shares predicted using the method of Devereux and Sutherland (2008) deliver perfect risk-sharing when $\psi = 0$, to a first-order approximation. As a result, these shares can also be derived by decentralizing the complete markets solution, as in Kollmann (2006) and Heathcote and Perri (2008).

[14] Data from the WFE is only available starting in 1990.

[15] Results are very similar if I set $\widehat{A}^H = 0.07$ and $A^F = 0.09$.

good model with persistent shocks only ($\phi = 2, \lambda = 0.75, \rho = 0.8$). The remaining parameters are calibrated as in Section 3.2.

Figure 2 presents impulse responses of capital stocks, dividends and equity prices to a one standard deviation shock to home country technology in the benchmark model with financial costs (solid lines). For comparison, I have also plotted the responses from the two good complete markets model (dashed lines). The dynamics of these variables are very similar across the two models. The main difference is that the path of the home equity price is higher – and the path of the foreign equity price lower – in the model with financial costs. In fact, the foreign equity price eventually dips slightly below its steady-state value in the benchmark model. This makes home and foreign equity prices less correlated (0.71) than they were under complete markets (0.99).

Figure 3 presents impulse responses of consumption, cross-border ownership shares, and numeraire valued cross-holdings. The top two panels show that the gap between home and foreign consumption is larger in the benchmark model with financial costs than in the complete markets model. This is a result of incomplete risk-sharing. After a positive, persistent productivity shock in the home country, home firms are much more valuable than foreign firms. This disproportionately benefits home households, since they own the larger stake in home firms. Home households enjoy greater lifetime wealth and a higher consumption path. The middle-left impulse response shows that home households gradually increase their ownership share of foreign equity.[16] Therefore, there are positive capital outflows from the home country for several periods following the shock. However, home households also increase their ownership share of *home* equity. Since equity is in fixed supply, foreign households must sell home equity to home households. This corresponds to *negative* capital inflows for several periods from the perspective of the home country, as shown in the middle-right panel. Eventually, the financial costs cause cross-border ownership shares to return to their steady-state levels.

It follows from the discussion above that each country's gross capital outflows are negatively correlated with gross capital inflows. How does this impact gross foreign assets and liabilities? The bottom two panels of Figure 3 show the impulse responses of the home country's gross foreign assets (paf) and gross foreign liabilities ($pah\_$). Both assets and liabilities rise on impact and stay high for several periods. The initial jump is mostly due to the jump in equity prices, because the initial capital flows are very small. However, liabilities eventually drop below their steady-state level. This occurs because foreigners continue to hold low levels of home equity even after the home equity price has returned to its steady-state value. The correlation between gross foreign assets and liabilities is still positive (0.62), but it is smaller than the cross-country correlation between equity prices (0.71).

[16]In the complete markets models, ownership shares are indeterminate.

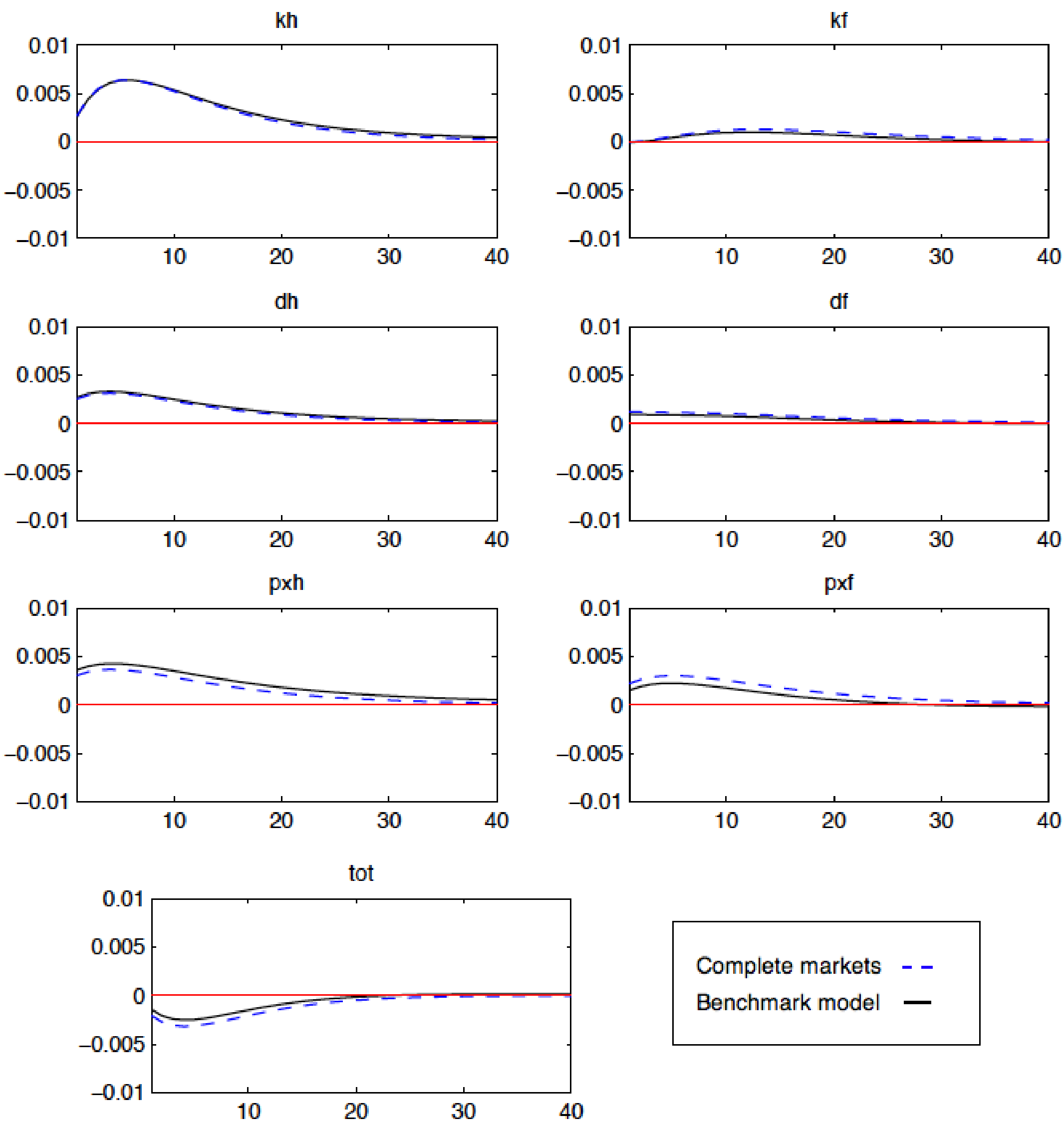

Figure 2: **Impulse responses to a one standard deviation shock to home country technology: two good benchmark model versus two good complete markets model.** The dashed lines are impulse responses in the two good complete markets version, and the solid lines are impulse responses in the benchmark model with financial costs. kh is the capital stock of home firms, kf is the capital stock of foreign firms, dh is dividends paid by home firms, df is dividends paid by foreign firms, pxh is the price of an equity share in home firms, pxf is the price of an equity share in foreign firms, and tot is the terms of trade (the price of home output goods divided by the price of foreign output goods).

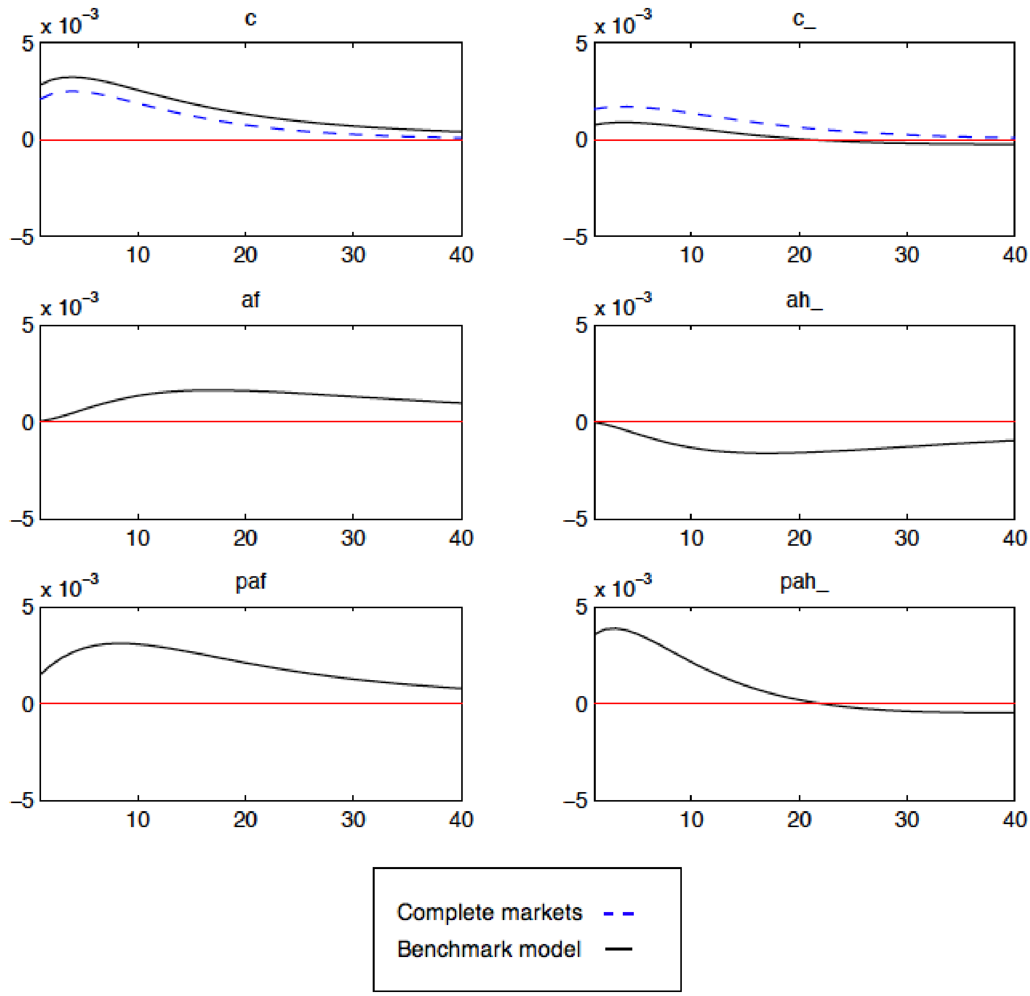

Figure 3: **Impulse responses to a one standard deviation shock to home country technology: two good benchmark model versus two good complete markets model.** The dashed lines are impulse responses in the two good complete markets version, and the solid lines are impulse responses in the benchmark model with financial costs. c is the home household's consumption of home consumption goods, c_{-} is the foreign household's consumption of foreign consumption goods, af is the home household's ownership share of foreign equity (benchmark model only), ah_{-} is the foreign household's ownership share of home equity (benchmark model only), paf is the home household's numeraire-valued holdings of foreign equity ("gross foreign assets" – benchmark model only), and pah_{-} is the foreign household's numeraire-valued holdings of home equity ("gross foreign liabilities" – benchmark model only).

4 FDI and portfolio equity

How do the business cycle properties of equity prices, flows and positions depend on the duration of the underlying investment project? To address this question, I develop an international real business cycle (IRBC) model of greenfield FDI and portfolio equity based on two simple distinctions. First, greenfield FDI finances investment in new projects, while portfolio equity finances ongoing operations. Second, greenfield FDI is "locked in" for a period of time before it produces any returns, while portfolio equity can be withdrawn at any point. I use the benchmark model from Section 3, modified to allow for investment projects of different durations.

4.1 Model

4.1.1 Firms

Firms in each country have an overlapping generations structure, with new firms born every period. A new firm acquires firm-specific capital for a two-period startup project by issuing new equity in the form of direct ownership claims. When the startup project completes, the firm pays a dividend to its initial owners and reinvests part of its output in an ongoing, single-period project. At this decision point, the firm undergoes an initial public offering: the direct owners sell their stakes, and the firm issues portfolio equity shares. At the end of the ongoing project, the firm pays a dividend to its portfolio owners and exits.

New (N) and ongoing (G) firms in the home country produce home output goods, while new and ongoing firms in the foreign country produce foreign output goods. Goods produced by new and ongoing firms within a country are identical. The only sources of uncertainty are two country-specific aggregate productivity shocks, Z_t^H and Z_t^F. Each country-specific shock impacts all new and ongoing firms in a particular country. Throughout this section, I focus on home firms; foreign firms are symmetric.

Figure 4 illustrates the overlapping-generations structure of firms. Every period, a mass of identical new firms is born and an aggregate productivity shock is realized. A new firm lives for four periods, or "stages". The following describes the actions that a firm born at time t takes at each stage. The firm described here is the bottom-most firm in the figure.

Stage 1: The firm issues equity at price $P_t^{N,H}$. It uses the proceeds to acquire firm-specific capital $K_t^{N,H}$, which it invests in a two-period startup project.

Stage 2: The firm cannot take any action at this stage. Its capital is sunk in the startup project.

Stage 3: The startup project finishes and yields its output. The firm chooses how much of this output to reinvest in a one-period ongoing project, $K_{t+2}^{G,H}$, and how much to pay out in dividends, $D_{t+2}^{N,H}$.

Stage 4: The ongoing project finishes and yields its output. The firm pays all of its output as dividends, $D_{t+3}^{G,H}$, and exits.

A new firm can do only one thing: issue an ownership claim at numeraire price $P_t^{N,H}$ and use the proceeds to acquire capital $K_t^{N,H}$. I assume that the firm can convert home output goods into capital one-for-one. The amount of capital the firm can create through share issuance is:

$$K_t^{N,H} = \frac{P_t^{N,H}}{P_t^H} \tag{27}$$

Now consider an ongoing firm (Stage 3) that has just completed its startup project in period t. This firm is the second from the top in the figure; it was born in period $t-2$. The output from the startup project is:

$$Y_t^{N,H} = Z_t^H \left(K_{t-2}^{N,H}\right)^\theta \ , \theta \in (0,1) \tag{28}$$

where $K_{t-2}^{N,H}$ is startup capital invested two periods ago and Z_t^H is the aggregate productivity shock affecting all firms in the home country. Given ongoing capital investment $K_t^{G,H}$, output from the ongoing project next period will be:

$$Y_{t+1}^{G,H} = Z_{t+1}^H \left(K_t^{G,H}\right)^\theta \tag{29}$$

Capital in ongoing firms depreciates at the rate $\delta \in [0,1]$ over one period, and capital in new firms depreciates at the rate $\delta_N = 1-(1-\delta)^2$ over two periods. At time t, the firm chooses ongoing capital investment, $K_t^{G,H}$, and today's dividend to the startup owners, $D_t^{N,H}$, to solve the following problem:

$$\max_{K_t^{G,H}, D_t^{N,H}} \left\{ D_t^{N,H} + E_t\left[M_{t+1,t} D_{t+1}^{G,H}\right]\right\}$$

$$\text{s.t. } D_t^{N,H} = P_t^H\left[Y_t^{N,H} + (1-\delta_N)K_{t-2}^{N,H} - K_t^{G,H}\right] \tag{30}$$

$$D_{t+1}^{G,H} = P_{t+1}^H\left[Y_{t+1}^{G,H} + (1-\delta)K_t^{G,H}\right] \tag{31}$$

As before, $M_{t+1,t}$ is the home household's intertemporal marginal rate of substitution (IMRS) of time-$(t+1)$ numeraire goods for time-t numeraire goods. Also recall that output and capital are measured in terms of home output goods, while dividends and prices are measured in terms of the numeraire. The first-order condition for the ongoing firm is:

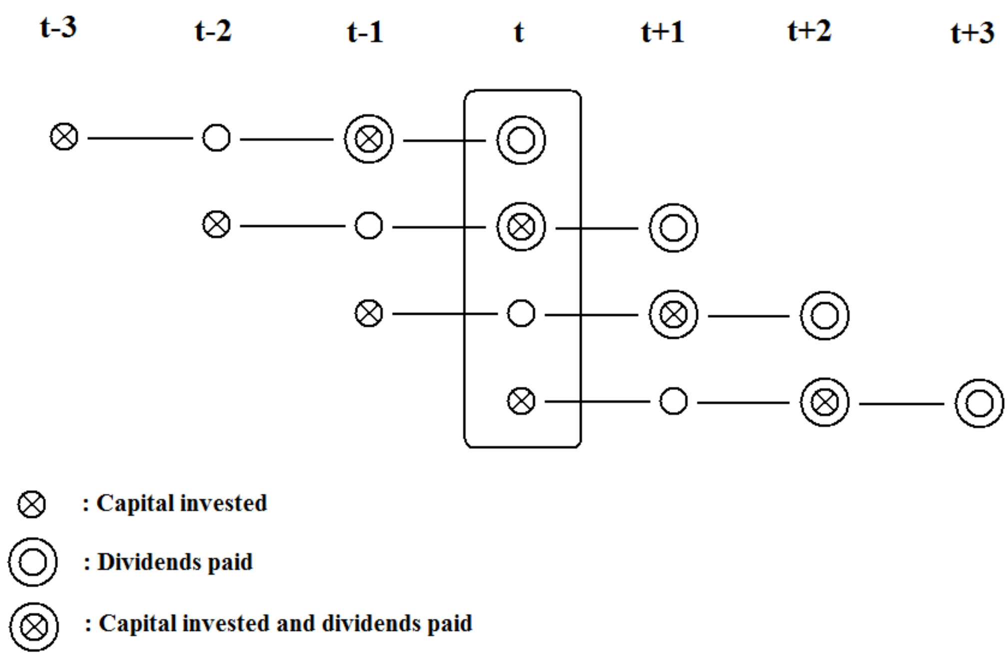

Figure 4: **Illustration of the overlapping generations structure of firms in the model of FDI and portfolio equity.**

$$1 = E_t \left[M_{t+1,t} \frac{P_{t+1}^H}{P_t^H} \left(\frac{\theta Y_{t+1}^{G,H}}{K_t^{G,H}} + 1 - \delta \right) \right] \tag{32}$$

4.1.2 Households

Households have the same preferences as in the benchmark model, but the budget constraint is different. Households in both countries can hold claims to four types of firms: new home firms, ongoing home firms, new foreign firms and ongoing foreign firms. The budget constraint for the representative home household is:

$$\begin{aligned} P_t C_t + P_t^{N,H} A_t^{N,H} + P_t^{N,F} A_t^{N,F} + P_t^{G,H} A_t^{G,H} + P_t^{G,F} A_t^{G,F} \\ = \left(P_t^{G,H} + D_t^{N,H} \right) A_{t-2}^{N,H} + \left(P_t^{G,F} + D_t^{N,F} \right) A_{t-2}^{N,F} \\ + D_t^{G,H} A_{t-1}^{G,H} + D_t^{G,F} A_{t-1}^{G,F} \\ - \frac{\psi}{2} P_t^F \left(A_t^{N,F} - A^{N,F} \right)^2 - \frac{\psi}{2} P_t^F \left(A_t^{G,F} - A^{G,F} \right)^2 \end{aligned} \tag{33}$$

where, for example, $A_t^{N,H}$ is the number of new home firms owned by home households at the end of time t. Note that the payoff to a new firm's direct ownership claim includes two components – the new firm's dividend plus the price of the ongoing firm. This reflects the assumption that the new firm's owners can sell their stakes at the end of the startup project. The payoff to a share in an ongoing firm is the final dividend, paid just before the firm exits.

The second-to-last term in (33) represents financial costs that the home household must pay whenever the number of new foreign firms owned differs from its steady-state value. Analogously, the last term represents costs paid whenever the number of shares in ongoing foreign firms differs from its steady-state value. The Appendix states the foreign household's budget constraint; it is the mirror image of the home household's budget constraint. The Appendix also gives the first-order conditions of the model.

4.1.3 Market clearing

Market-clearing for output goods requires:

$$K_t^{N,H} - (1 - \delta_N) K_{t-2}^{N,H} + K_t^{G,H} - (1 - \delta) K_{t-1}^{G,H} + C_t^H + \widehat{C}_t^H = Y_t^{N,H} + Y_t^{G,H} - \Omega_t^H \tag{34}$$

$$K_t^{N,F} - (1 - \delta_N) K_{t-2}^{N,F} + K_t^{G,F} - (1 - \delta) K_{t-1}^{G,F} + C_t^F + \widehat{C}_t^F = Y_t^{N,F} + Y_t^{G,F} - \Omega_t^F \tag{35}$$

Here Ω_t^H represents costs paid by foreign households to deviate from their long-run holdings of home equity, and Ω_t^F represents costs paid by home households to deviate from their long-run holdings of foreign equity.[17] In the calibrated model, these terms are very small.

I normalize the supply of each security to one:

$$1 = A_t^{N,H} + \widehat{A}_t^{N,H} \quad (36)$$
$$1 = A_t^{G,H} + \widehat{A}_t^{G,H} \quad (37)$$
$$1 = A_t^{N,F} + \widehat{A}_t^{N,F} \quad (38)$$
$$1 = A_t^{G,F} + \widehat{A}_t^{G,F} \quad (39)$$

I refer to $A_t^{N,F}$ and $\widehat{A}_t^{N,H}$ as the *cross-border ownership shares of new firms*, and I refer to $A_t^{G,F}$ and $\widehat{A}_t^{G,H}$ as the *cross-border ownership shares of ongoing firms.*

The shock processes are the same as in Section 3.

4.1.4 Equilibrium

A competitive equilibrium is a sequence of prices and allocations such that all markets clear when consumers and firms behave optimally, taking equilibrium prices as given.

4.2 Results

I interpret home (foreign) holdings of new foreign (home) firms as the greenfield FDI assets (liabilities) of the home country, and I interpret home (foreign) holdings of ongoing foreign (home) firms as gross portfolio equity assets (liabilities). The calibration is very similar to the benchmark model with financial costs; see Sections 3.2 through 3.4 for a discussion. I set $\widehat{A}^{N,H} = \widehat{A}^{G,H} = A^{N,F} = A^{G,F} = 0.08$. So the cross-border ownership shares are 8%, both for new firms ("greenfield FDI") and for ongoing firms ("portfolio equity"). I report results for the two good version with persistent shocks only ($\phi = 2, \lambda = 0.75, \rho = 0.8$). I recalibrate σ_H and σ_F to 0.010 to match the standard deviation of U.S. GDP, and I recalibrate the cross-border cost parameter ψ to 2.0 to match the standard deviation of the U.S. current-account-to-GDP ratio.

Figure 5 presents impulse responses of physical capital, dividends and equity prices to a one standard deviation shock to home country technology. Responses are shown both for new firms (dashed lines) and for ongoing firms (solid lines). The capital stock of new home firms rises less on impact than the the capital stock of ongoing home firms. Because technology shocks are only partially persistent, expected technology for new firms two periods ahead is less than expected

[17] These terms are given by:

$$\Omega_t^H \equiv \frac{\psi}{2}\left(\widehat{A}_t^{N,H} - \widehat{A}^{N,H}\right)^2 + \frac{\psi}{2}\left(\widehat{A}_t^{G,H} - \widehat{A}^{G,H}\right)^2$$
$$\Omega_t^F \equiv \frac{\psi}{2}\left(A_t^{N,F} - A^{N,F}\right)^2 + \frac{\psi}{2}\left(A_t^{G,F} - A^{G,F}\right)^2$$

Note that Ω_t^H and Ω_t^F are measured in units of home and foreign output goods, respectively.

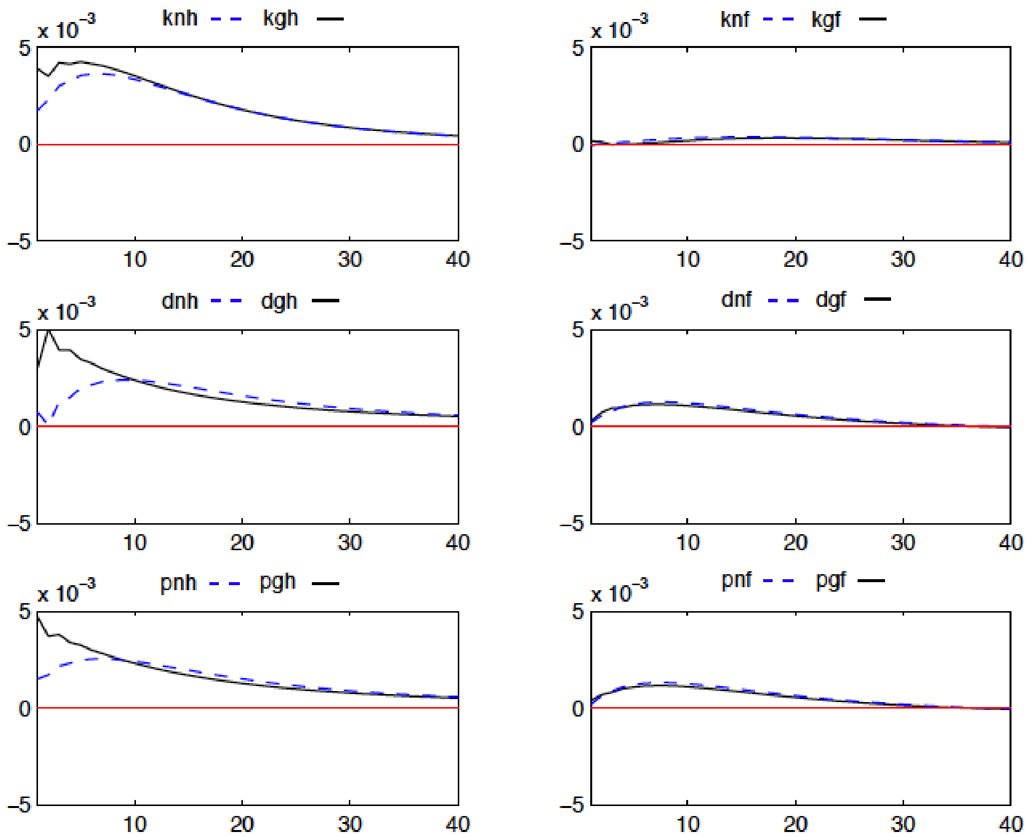

Figure 5: **Impulse responses to a one standard deviation shock to home country technology: FDI and portfolio equity model with two goods.** The dashed lines are impulse responses for new firms, and the solid lines are responses for ongoing firms. knh is the capital stock of new home firms, kgh is the capital stock of ongoing home firms, knf is the capital stock of new foreign firms, kgf is the capital stock of ongoing foreign firms, dnh is dividends paid by new home firms, dgh is dividends paid by ongoing home firms, dnf is dividends paid by new foreign firms, dgf is dividends paid by ongoing foreign firms, pnh is the price of a claim to a new home firm, pgh is the price of an equity share in ongoing home firms, pnf is the price of a claim to a new foreign firm, and pgf is the price of an equity share in ongoing foreign firms.

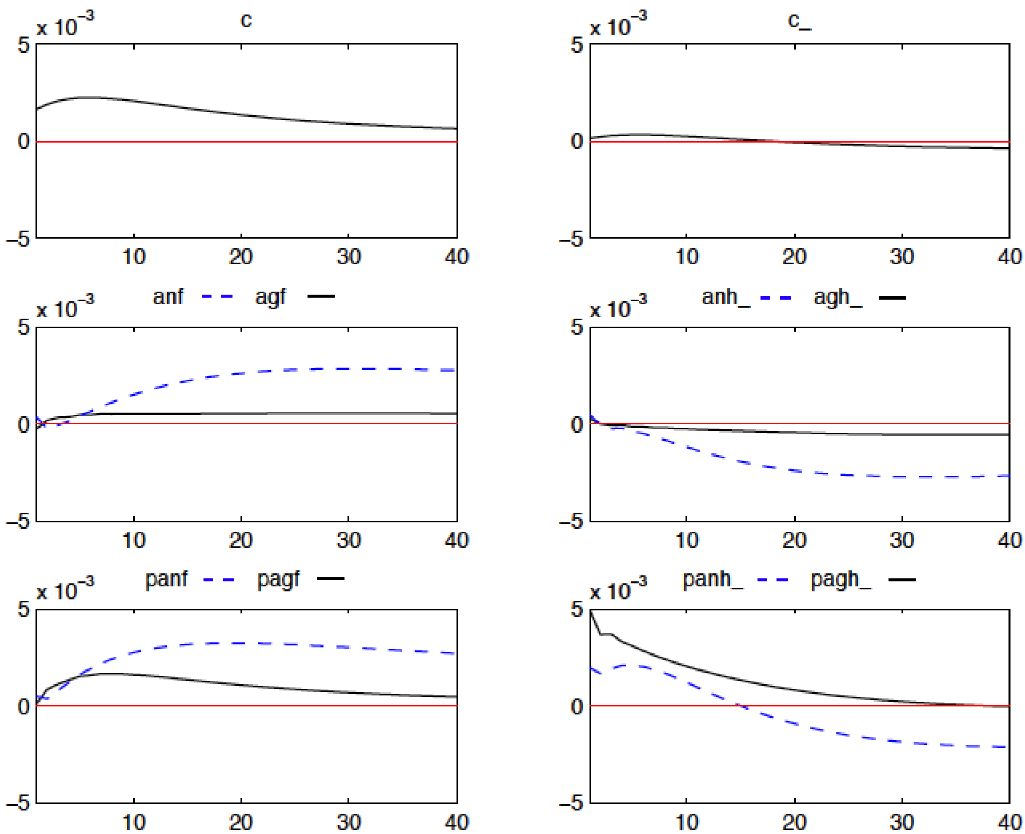

Figure 6: **Impulse responses to a one standard deviation shock to home country technology: FDI and portfolio equity model with two goods.** c is the home household's consumption of home consumption goods, c_{-} is the foreign household's consumption of foreign consumption goods, anf is the home household's ownership share of new foreign firms, agf is the home household's ownership share of foreign ongoing-firm equity, anh_{-} is the foreign household's ownership share of new home firms, agh_{-} is the foreign household's ownership share of home ongoing-firm equity, $panf$ is the home household's numeraire-valued holdings of new foreign firms ("gross greenfield FDI assets"), $pagf$ is the home household's numeraire-valued holdings of foreign ongoing-firm equity ("gross portfolio equity assets"), $panh_{-}$ is the foreign household's numeraire-valued holdings of new home firms ("gross greenfield FDI liabilities"), and $pagh_{-}$ is the foreign household's numeraire-valued holdings of home ongoing-firm equity ("gross portfolio equity liabilities").

	peo, y	pei, y	gro, y	gri, y	peo, pei	gro, gri
FDI/PE Model	0.22	-0.22	0.38	-0.38	-1.00	-1.00
U.S. Data	0.17	0.40	0.08	0.16	0.27	0.79

Table 6: **Summary of model results for the cyclicality of portfolio equity (PE) and greenfield FDI flows.** *peo* is real gross PE outflows, *pei* is real gross PE inflows, *gro* is real gross greenfield FDI outflows, *gri* is real gross greenfield FDI inflows, and *y* is real GDP.

technology for ongoing firms tomorrow. In addition, new firms are exposed to greater risk: they face two innovations to technology before production occurs. As a result, new firms invest less on impact. Dividends and equity prices also adjust more gradually for new home firms. Equity prices for new firms are still positively correlated across countries (0.61), as are equity prices for ongoing firms (0.49).

Figure 6 presents impulse responses of home and foreign consumption, cross-border ownership shares, and numeraire-valued cross-holdings. *panf* represents the gross greenfield FDI assets of the home country, *panh_* represents gross greenfield FDI liabilities, *pagf* represents gross portfolio equity (PE) assets, and *pagh_* represents gross PE liabilities. As in the benchmark model with financial costs, the path of home consumption is significantly higher than the path of foreign consumption. After the shock, home households gradually increase their ownership shares of new and ongoing foreign firms, and foreign households gradually decrease their ownership shares of new and ongoing home firms. These changes reflect wealth effects favoring the home country, as discussed in Section 3.4.[18] However, capital flows are smaller in portfolio equity than in greenfield FDI. Recall that equity prices in the model are positively correlated across countries in both asset classes, while capital flows are negatively correlated. Because capital flows are small in PE, the price effect dominates, and the correlation between gross PE assets and liabilities is positive (0.58). In contrast, for FDI, the capital flow effect dominates, and the correlation between gross FDI assets and liabilities is negative (-0.79).

Although the quantitative effects of capital flows differ for new versus ongoing firms, the results are qualitatively very similar. After a positive productivity shock in the home country, the home household increases its ownership shares of all four types of equity, and the foreign household's ownership shares all fall. Therefore, gross capital outflows and inflows are negatively correlated in the model, both for greenfield FDI and PE. Furthermore, the negative correlation is nearly perfect. Table 6 presents selected business cycle statistics for capital flows in the model. Home's gross capital outflows are positively correlated with domestic output, both for PE (0.22) and for greenfield FDI (0.38). In contrast, home's gross capital inflows are countercyclical, both for PE (-0.22) and for greenfield FDI (-0.38). The procyclical gross outflows predicted by the model are at least qualitatively consistent with U.S. data; however, the countercyclical gross inflows are

[18] Although the changes in cross-border ownership shares are very long-lived in this calibration, the shares do eventually return to their steady-state levels.

not. The model's prediction of a strong negative correlation between outflows and inflows is also counterfactual.

5 Conclusion

This paper has documented a strong positive correlation between gross equity-based assets and liabilities in the G7. This correlation reflects strong cross-country correlation between equity prices and moderate comovement of gross outflows and inflows. I then analyzed an international real business cycle (IRBC) model under several different assumptions to evaluate possible causes of these correlations: diminishing marginal product of capital, imperfect substitutability of goods, incomplete markets, and investment project duration. I showed that a complete markets model with diminishing returns to capital predicts close cross-country correlation between equity prices. Adding imperfect substitutability between goods strengthened this result, because the terms of trade help to propagate productivity shocks across countries. In contrast, an incomplete markets model with realistically underdiversified ownership shares introduced negative correlation between outflows and inflows, which weakened the correlation between gross foreign assets and liabilities. Finally, I developed a model of greenfield FDI and portfolio equity. The model suggests that assets and liabilities should be more closely correlated in portfolio equity than in greenfield FDI.

Many avenues are open for future research. A natural extension of the FDI/PE model would include debt finance. Bonds are an important component of international asset trade, and they account for a large fraction of U.S. gross liabilities. It would also be useful to extend the framework to emerging countries, where portfolio inflows tend to be very volatile and FDI inflows are often countercyclical. One approach is to introduce financial constraints in one country, as in Albuquerque (2003) or Smith and Valderrama (2009). Such a framework may help explain FDI and portfolio dynamics in emerging countries, like China, that can influence world prices despite having limited domestic financial markets.

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Appendix

A Data sources

This section describes the data used to compute business cycle statistics for the U.S. and G7 gross equity positions. The source data (time series) for Tables 1 through 3 are as follows:

- fda_n: Gross foreign direct investment (FDI) assets, at market value, in current U.S. dollars. Source: Lane and Milesi-Ferretti (2007) (LM)
- pea_n: Gross portfolio equity (PE) assets, at market value, in current U.S. dollars. Source: LM
- fdl_n: Gross FDI liabilities, at market value, in current U.S. dollars. Source: LM
- pel_n: Gross PE liabilities, at market value, in current U.S. dollars. Source: LM
- fdo_n: Gross FDI outflows in current U.S. dollars. Source: UNCTAD's World Investment Report (WIR)
- peo_n: Gross PE outflows in current U.S. dollars. Source: IMF's International Financial Statistics (IFS)
- fdi_n: Gross FDI inflows in current U.S. dollars. Source: WIR
- pei_n: Gross PE inflows in current U.S. dollars. Source: IFS
- y: Real GDP in constant 2000 U.S. dollars. Source: World Bank's World Development Indicators (WDI)
- y_n^g: World GDP in current U.S. dollars. Source: IMF's World Economic Outlook (WEO)
- y^g: Real world GDP in constant 2000 U.S. dollars. Source: Author's calculations using y_n^g and annual real GDP growth rates from WEO

The n subscripts above indicate that a variable is nominal. Real variables carry no subscript.

All data sets measure FDI in accordance with the IMF's Balance of Payments manual. Accordingly, FDI consists of any cross-border equity transaction that involves an investor in one country acquiring a "lasting interest" in a foreign firm. In practice, an investor is assumed to obtain a lasting interest if he or she acquires 10% or more of a firm's outstanding equity; but other transactions can be counted as FDI if there is evidence that the investor gained "an effective voice in management." Greenfield investments – an investor in one country starting a new firm in a foreign country – are an important form of FDI. Finally, financial transactions between parents and foreign subsidiaries are also counted as FDI. Cross-border equity purchases that do not qualify as FDI (typically because they lead to less than 10% ownership) are classified as portfolio equity.

Data from Lane and Milesi-Ferretti (2007) covers 1970 – 2004 and is only available at an annual frequency. The world GDP series from WEO is available starting in 1980. Most of the data from UNCTAD and IFS covers at least 1980 – 2004. Two exceptions are France, for which portfolio equity flows are only available starting in 1983; and Italy, for which portfolio equity inflows are only available starting in 1989. I restrict my attention to the years 1980 – 2004, using shorter samples when necessary for France and Italy.

I compute total equity-based assets, liabilities, outflows and inflows as follows:

- $eqa_n = fda_n + pea_n$: Gross FDI plus portfolio equity (PE) assets in current U.S. dollars
- $eql_n = fdl_n + pel_n$: Gross FDI plus PE liabilities in current U.S. dollars
- $eqo_n = fdo_n + peo_n$: Gross FDI plus PE outflows in current U.S. dollars
- $eqi_n = fdi_n + pei_n$: Gross FDI plus PE inflows in current U.S. dollars

I compute valuation effects as follows. Consider FDI assets (fda_n) as an example. For each year ($t = 1981 - 2004$), I compute the change in FDI assets from the end of the prior year to the end of the current year: $\Delta fda_{n,t} = fda_{n,t} - fda_{n,t-1}$. I then subtract gross FDI outflows in time t: $fdav_{n,t} \equiv \Delta fda_{n,t} - fdo_{n,t}$. The difference, $fdav_{n,t}$, is the valuation effect: the capital gain or loss on the prior year's FDI assets. I use an analogous technique to compute valuation effects for PE assets ($peav_n$), FDI liabilities ($fdlv_n$) and PE liabilities ($pelv_n$). Finally, I compute total valuation effects for assets and liabilities: $eqav_n = fdav_n + peav_n$ and $eqlv_n = fdlv_n + pelv_n$.

I work with real time series expressed in constant 2000 U.S. dollars. To do so, I first compute a global GDP deflator as follows:

- $p^g = y_n^g / y^g$: Global GDP deflator (2000 = 1)

I then divide each nominal variable by the global GDP deflator to obtain a real time series; e.g., $fda = fda_n / p^g$. These series, along with y, are the ones used to compute business cycle statistics. I apply a Hodrick-Prescott filter to each real series using a smoothing parameter of 6.25, which is the value that Ravn and Uhlig (2002) suggest for annual data. Note that I filter actual data only, not simulated model data.

For Tables 4 and 5, from 1987 – 2004, I have two additional source variables:

- mao_n: Gross merger and acquisition (MA) outflows in current U.S. dollars. Source: WIR
- mai_n: Gross MA inflows in current U.S. dollars. Source: WIR

Following Calderón et al. (2004), I obtain a rough proxy for greenfield flows by subtracting MA from total flows:

- $gro_n = fdo_n - mao_n$: Gross greenfield FDI outflows in current U.S. dollars
- $gri_n = fdi_n - mai_n$: Gross greenfield FDI inflows in current U.S. dollars

I then deflate and detrend these variables as described above.

B Additional model details

B.1 Benchmark model (Section 3)

B.1.1 Foreign household's problem

The preferences for foreign households are:

$$E_t \left[\sum_{j=0}^{\infty} \beta^j \frac{\widehat{C}_{t+j}^{1-\gamma}}{1-\gamma} \right] \tag{40}$$

where $\widehat{C}_t$ is a CES aggregate of home and foreign output goods:

$$\widehat{C}_t = \left[(1-\lambda)^{\frac{1}{\phi}} \left(\widehat{C}_t^H \right)^{\frac{\phi-1}{\phi}} + \lambda^{\frac{1}{\phi}} \left(\widehat{C}_t^F \right)^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}} \tag{41}$$

Here $\widehat{C}_t^H$ and $\widehat{C}_t^F$ denote the foreign household's consumption of home and foreign output goods, respectively. The budget constraint for foreign households is:

$$\begin{gathered} \widehat{P}_t \widehat{C}_t + P_t^{X,H} \widehat{A}_t^H + P_t^{X,F} \widehat{A}_t^F = \\ (P_t^{X,H} + D_t^H) \widehat{A}_{t-1}^H + (P_t^{X,F} + D_t^F) \widehat{A}_{t-1}^F - \frac{\psi}{2} P_t^H \left(\widehat{A}_t^H - \widehat{A}^H \right)^2 \end{gathered} \tag{42}$$

Here $\widehat{A}_t^H$ and $\widehat{A}_t^F$ denote the number of shares of home and foreign equity held by the foreign household at the end of time t, and $\widehat{A}^H$ is the long-run (steady-state) value for $\widehat{A}_t^H$. Note that the financial costs on foreign short-run holdings of home equity are paid in units of home output goods. The foreign household's problem is to maximize (40) subject to (41) and (42).

B.1.2 Foreign firm's problem

The foreign firm's production function is:

$$Y_t^F = Z_t^F \left(K_{t-1}^F \right)^{\theta} \tag{43}$$

Here K_{t-1}^F is the foreign firm's capital stock at the end of period $t-1$, available for production in period t; Y_t^F is the output produced by the foreign firm; and Z_t^F is an aggregate productivity shock affecting all firms operating in the foreign country. Foreign firms solve the following problem:

$$\begin{gathered} \max_{K_t^F, D_t^F} D_t^F + \sum_{j=1}^{\infty} \widehat{M}_{t+j,t} D_{t+j}^F \\ \text{s.t. } D_t^F = P_t^F \left[Y_t^F + (1-\delta) K_{t-1}^F - K_t^F \right] \end{gathered} \tag{44}$$

B.1.3 Additional first-order conditions

The home household's first-order conditions for home and foreign output goods are:

$$\frac{C_t^H}{C_t} = \lambda \left(\frac{P_t^H}{P_t} \right)^{-\phi} \tag{45}$$

$$\frac{C_t^F}{C_t} = (1-\lambda) \left(\frac{P_t^F}{P_t} \right)^{-\phi} \tag{46}$$

The foreign household's first-order conditions for home and foreign output goods are:

$$\frac{\widehat{C}_t^H}{\widehat{C}_t} = (1-\lambda) \left(\frac{P_t^H}{\widehat{P}_t} \right)^{-\phi} \tag{47}$$

$$\frac{\widehat{C}_t^F}{\widehat{C}_t} = \lambda \left(\frac{P_t^F}{\widehat{P}_t} \right)^{-\phi} \tag{48}$$

The foreign firm's first-order condition is:

$$1 = E_t \left[\widehat{M}_{t+1,t} \frac{P_{t+1}^F}{P_t^F} \left(\frac{\theta Y_{t+1}^F}{K_t^F} + 1 - \delta \right) \right] \tag{49}$$

B.2 FDI and portfolio equity (Section 4)

B.2.1 Foreign household's budget constraint

The foreign household's budget constraint is:

$$\begin{aligned} &\widehat{P}_t \widehat{C}_t + P_t^{N,H} \widehat{A}_t^{N,H} + P_t^{N,F} \widehat{A}_t^{N,F} + P_t^{G,H} \widehat{A}_t^{G,H} + P_t^{G,F} \widehat{A}_t^{G,F} \\ &= \left(P_t^{G,H} + D_t^{N,H} \right) \widehat{A}_{t-2}^{N,H} + \left(P_t^{G,F} + D_t^{N,F} \right) \widehat{A}_{t-2}^{N,F} \\ &\quad + D_t^{G,H} \widehat{A}_{t-1}^{G,H} + D_t^{G,F} \widehat{A}_{t-1}^{G,F} \\ &\quad - \frac{\psi}{2} P_t^H \left(\widehat{A}_t^{N,H} - \widehat{A}^{N,H} \right)^2 - \frac{\psi}{2} P_t^H \left(\widehat{A}_t^{G,H} - \widehat{A}^{G,H} \right)^2 \end{aligned} \tag{50}$$

B.2.2 Additional first-order conditions

The first-order condition for the foreign ongoing firm is:

$$1 = E_t \left[\widehat{M}_{t+1,t} \frac{P_{t+1}^F}{P_t^F} \left(\frac{\theta Y_{t+1}^{G,F}}{K_t^{G,F}} + 1 - \delta \right) \right] \tag{51}$$

The home household's first-order conditions for C_t^H and C_t^F – and the foreign household's first-order conditions for $\widehat{C}_t^H$ and $\widehat{C}_t^F$ – are unchanged from the benchmark model. The home household's first-order conditions for equity holdings are:

$$1 = E_t \left[M_{t+2,t} R^{N,H}_{t+2} \right] \tag{52}$$

$$1 = E_t \left[M_{t+2,t} R^{*N,F}_{t+2} \right] \tag{53}$$

$$1 = E_t \left[M_{t+1,t} R^{G,H}_{t+1} \right] \tag{54}$$

$$1 = E_t \left[M_{t+1,t} R^{*G,F}_{t+1} \right] \tag{55}$$

$$\text{where } M_{t+j,t} \equiv \frac{\beta^j C^{-\gamma}_{t+j} P^{-1}_{t+j}}{C^{-\gamma}_t P^{-1}_t} \tag{56}$$

And the foreign household's first-order conditions for equity holdings are:

$$1 = E_t \left[\widehat{M}_{t+2,t} R^{*N,H}_{t+2} \right] \tag{57}$$

$$1 = E_t \left[\widehat{M}_{t+2,t} R^{N,F}_{t+2} \right] \tag{58}$$

$$1 = E_t \left[\widehat{M}_{t+1,t} R^{*G,H}_{t+1} \right] \tag{59}$$

$$1 = E_t \left[\widehat{M}_{t+1,t} R^{G,F}_{t+1} \right] \tag{60}$$

$$\text{where } \widehat{M}_{t+j,t} \equiv \frac{\beta^j \widehat{C}^{-\gamma}_{t+j} \widehat{P}^{-1}_{t+j}}{\widehat{C}^{-\gamma}_t \widehat{P}^{-1}_t} \tag{61}$$

Equity returns are as follows:

$$R^{N,H}_{t+2} \equiv \frac{P^{G,H}_{t+2} + D^{N,H}_{t+2}}{P^{N,H}_t} \tag{62}$$

$$R^{N,F}_{t+2} \equiv \frac{P^{G,F}_{t+2} + D^{N,F}_{t+2}}{P^{N,F}_t} \tag{63}$$

$$R^{G,H}_{t+1} \equiv \frac{D^{G,H}_{t+1}}{P^{G,H}_t} \tag{64}$$

$$R^{G,F}_{t+1} \equiv \frac{D^{G,F}_{t+1}}{P^{G,F}_t} \tag{65}$$

$$R_{t+2}^{*N,H} \equiv \frac{P_{t+2}^{G,H} + D_{t+2}^{N,H}}{P_t^{N,H} + \psi P_t^H \left(\widehat{A}_t^{N,H} - \widehat{A}^{N,H}\right)} \tag{66}$$

$$R_{t+2}^{*N,F} \equiv \frac{P_{t+2}^{G,F} + D_{t+2}^{N,F}}{P_t^{N,F} + \psi P_t^F \left(A_t^{N,F} - A^{N,F}\right)} \tag{67}$$

$$R_{t+1}^{*G,H} \equiv \frac{D_{t+1}^{G,H}}{P_t^{G,H} + \psi P_t^H \left(\widehat{A}_t^{G,H} - \widehat{A}^{G,H}\right)} \tag{68}$$

$$R_{t+1}^{*G,F} \equiv \frac{D_{t+1}^{G,F}}{P_t^{G,F} + \psi P_t^F \left(A_t^{G,F} - A^{G,F}\right)} \tag{69}$$

C Solution method

The models are amenable to standard perturbation techniques. I derive the unique non-stochastic steady-state analytically. For the model of FDI and portfolio equity (Section 4), I use a numerical technique to pin down some steady-state values, such as the capital stocks of new firms. I then use DYNARE to take a second-order Taylor approximation and solve for second-order policy functions. I verify that there is a unique stationary transition path. Since the model has no trend, I do not filter simulated model data. The business cycle correlations I report are the theoretical moments reported by DYNARE. Results from simulations using the pruning algorithm of Kim et al. (2008) are broadly similar.