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Abstract

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JEL Classification: C62, F31, G12

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BKK the EZ Way

International Long-Run Growth News and Capital Flows

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Abstract

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1 Introduction

Does capital always flow to the most productive countries? Does it matter whether productivity improvements are deemed to be short-lived or long lasting? In this paper we answer these questions by investigating the impact of short- and long-term productivity risk on international risk-sharing and capital flows among developed and integrated G7 countries.

We follow Bansal et al. (2010) and Colacito and Croce (2011) in identifying short- and long-run innovations to productivity by regressing Solow residuals on lagged country-specific price-dividend ratios. In a second step, we take the United States as the home country and connect the innovations of its net exports to relative short- and long-run productivity news with an aggregate of the remaining countries (Canada, France, Germany, Italy, Japan, and the United Kingdom).

Countries receiving good short-run productivity shocks experience an inflow of capital, that is, their net exports deteriorate. This is consistent with the observation that domestic net exports are negatively correlated with domestic output. Positive long-run news, in contrast, produces immediate and persistent capital outflows.

We then examine our findings through the lens of a frictionless international production based setting. In the context of a benchmark Backus, Kehoe, and Kydland (1994) (henceforth BKK) model, our empirical results represent an anomaly, since this setting cannot produce an immediate and sizeable outflow of capital goods upon the arrival of positive long-run productivity news. This anomaly vanishes once we introduce Epstein and Zin (1989) (henceforth EZ) preferences and analyze the resulting recursive risk-sharing motive.

Specifically, agents with EZ preferences dislike both low expected levels of wealth and increasing uncertainty about their future utility profiles as long as the intertemporal elasticity of substitution (IES) is larger than the reciprocal of their relative risk aversion (RRA). Equivalently, positive long-run growth news directly depresses marginal utilities and is priced independently of short-run consumption growth variations.

The key economic insight underlying our result is the existence of a tension between two channels. On the one hand, the *productivity channel* suggests that resources should move from the least productive to the most productive country; on the other hand, the *risk-sharing channel* suggests that resources should flow from the low-marginal-utility country to the high-marginal-utility country. The relative intensity of these two channels depends on the relative relevance of short- and long-run shocks in the determination of marginal utilities across countries.

In our model (henceforth EZ-BKK), the productivity channel always dominates with respect to short-run growth shocks, that is, the most productive country receives resources from abroad and invests more. This result is well known, as it holds also in the BKK model with standard preferences. The novelty of our analysis has to do with the response to long-run productivity news.

With recursive preferences, the country that is expected to be more productive in the long run immediately experiences a substantial drop in its marginal utility, even though productivity has not yet changed. Unlike in the case of a positive short-run shock, the risk-sharing channel dominates, and it prescribes an immediate net outflow of goods followed by a slow recovery of net exports. With time-additive preferences, in contrast, the outflow of resources unfolds only with several periods of delay, as productivity gains are realized over time.

From a quantitative perspective, a conservative calibration of our EZ-BKK model produces responses of both the total and the capital goods net exports reasonably close to the data. An extended version of the model featuring the capital accumulation friction proposed by Ai et al. (2013) can also account for (i) a large equity risk premium, and (ii) a strong countercyclicality of the net exports. In our model, consumption growth rates are internationally more correlated than output growth rates. This is what BKK call the quantity anomaly. We leave the full resolution of this puzzle to future research.

In the next subsection we discuss other related literature. In section 2 we present our empirical evidence. In section 3, we provide the main intuition of our EZ-BKK model in a two-period model, and in section 4, we present our infinite horizon model and our equilibrium conditions. In section 5 we discuss our results as well as an extension of our benchmark model. Section Appendix C.4 presents our sensitivity analysis and section 7 concludes.

1.1 Related Literature

Using the recursive methods in Anderson (2005) and Colacito and Croce (2013) for economies with multiple agents and recursive preferences, Tretvoll (2012) is the first to study a production economy with capital accumulation and recursive preferences. We differ from Tretvoll (2012) in two respects. First of all, Tretvoll does not consider long-run shocks, which constitute the main element of our theoretical and empirical investigations. Second, Tretvoll takes into consideration only a standard BKK capital accumulation setting with an IES smaller than 1 and an RRA of 100. We adopt a calibration in the spirit of Bansal and Yaron (2004), with an RRA of 10 and an IES slightly larger than 1.

We use Greenwood et al. (1988) preferences to bundle consumption and leisure in order to address the critique by Raffo (2008) regarding the sources of countercyclicality of net exports. We differ from these studies in our long-run risk approach with recursive preferences. Ai et al. (2013) do not address international dynamics. Colacito and Croce (2013) look at international dynamics, abstracting away from production activity and international investment flows, that is, the main focus of our study. Similarly to the present study, Coeurdacier et al. (2012) use recursive preferences, but their goal is to address the benefits of financial integration across heterogeneous countries in a one-good production economy.

Several studies have highlighted the role of real, informational, and financial frictions (among others, see Baxter and Crucini (1995), Kehoe and Perri (2002), Corsetti et al. (2008), Heathcote and Perri (2002, 2004, 2013), Petrosky-Nadeau (2011), Alessandria et al. (2011), and Van Nieuwerburgh and Veldkamp (2008)). Our analysis differs from these papers in its emphasis on long-term risk and recursive preferences in the context of a frictionless economy.

Beginning with Lucas (1990), several studies have focused on the role of international capital and financial flows across developed and emerging economies (see Lewis (2011) and Gourinchas and Rey (2013) for a complete review of this literature). We differ from these studies in several respects. First, because of our recursive risk-sharing approach to international trade, our focus is on developed economies only. Second, in contrast to several prior papers that have studied the composition of the international flow of financial assets, we focus on the trade of goods and services for consumption and investment reasons. Third, and most importantly, our analysis is the first to explore the general equilibrium implications of investment flows in the face of short- and long-run productivity news. Looking at transient dynamics among developed and integrated countries, we find that upon the realization of good long-run news, capital goods flow from relatively richer to relatively poorer countries.

From an empirical point of view, we expand the methodology used in previous work (Colacito and Croce (2011, 2013)) to show that country-specific long-run shocks have a well-identified negative impact on contemporaneous investment flows, consistent with our EZ-BKK model. Our findings are broadly consistent with the international empirical investigation of Kose et al. (2003, 2008), as we do find evidence of a highly correlated economic productivity factor across G-7 countries in our post-1970 sample.

In this paper, we refer to short- and long-run shocks as innovations that affect the growth rate of productivity for one and multiple periods, respectively. The literature often distinguishes between permanent and transitory shocks (see, among others, Kaltenbrunner and Lochstoer (2010) and Favilukis and Lin (2013)). Given our setup, short-run shocks are permanent innovations to the level of productivity. From a finance perspective, we provide a productivity-based general equilibrium explanation of the findings in Pavlova and Rigobon (2007), as our long-run productivity news endogenizes their exogenous marginal utility shocks.

2 Empirical Findings

In this section, we provide evidence on the differential response of international capital flows to shocks to the *expected* and to the *unanticipated* components of the growth rate of productivity. The empirical strategy that we discuss in this section needs to be interpreted as a purely descriptive device which becomes of interest when its implications are compared with those of the structural model that we discuss in section 4. Furthermore, in section 6 we formally interpret this system of equations as an auxiliary model that can be used to estimate the structural parameters that govern the transition dynamics of productivity in our economic model.

2.1 Using asset prices to learn about productivity fluctuations

We use the insight from Beaudry and Portier (2006) that asset prices contain information about future productivity to decompose the growth rate of productivity into an expected and an unanticipated component. Specifically, we regress the growth rate of productivity onto the lagged price-to-dividend ratio

$$\Delta a_t \quad = \quad \beta_a \cdot pd_{t-1} + \varsigma \cdot \varepsilon_{a,t}, \tag{1}$$

and interpret $z_{t-1} = \beta_a pd_{t-1}$ as the conditional expectation of the growth rate of productivity and the residual $\varepsilon_{a,t}$ as the unanticipated component of productivity. Furthermore, we exploit the autoregressive nature of price-to-dividend ratios to obtain an estimate of the shocks to the expected component of productivity ($\varepsilon_{z,t}$) by estimating the following equation:

$$z_t = \varrho z_{t-1} + \varsigma_z \cdot \varsigma \cdot \varepsilon_{z,t}. \tag{2}$$

As in Beaudry and Portier (2006), asset prices shocks do not immediately affect the growth rate of productivity and hence they represent pure growth news shocks.

Equations (1) and (2) can be motivated on several grounds. First, in our model, the market value of capital (Tobin's Q) is mainly driven by the conditional expectation of productivity growth. While Tobin's Q is highly correlated with the price-to-dividend ratio (see, among others, Beaudry and Portier (2006), Ai et al. (2013), and Croce (2014)), the latter is available for a large cross section of countries and over long sample periods.[1] This makes pd ratios preferable for empirical applications. As a result, equation (1) holds approximately as an equilibrium outcome. Indeed, when we run the same regression using simulated data the resulting estimates are reasonably close to their empirical counterparts.

Second, in section 6 we include equations (1) and (2) in an auxiliary model that enables us to tightly identify the key parameters of our structural risk-sharing model through indirect inference (see Gourieroux et al. (1993)). As part of an auxiliary model, equations (1)–(2) need not be correctly specified; rather we use them to select aspects of the data upon which to focus our analysis, that is, the response of international macroeconomic variables to news shocks.

In the interest of space, we report the results of the estimation of (1) and (2) in Appendix B.1.

2.2 Countries and data sources

We focus our empirical analysis on G7 countries. We aggregate countries as US versus the Rest of the World (henceforth RoW) to facilitate the comparison between our empirical results and the two-country model presented in the next section. RoW is an aggregate of the 6 remaining G7 countries (Canada, France, Germany, Italy, Japan, and the United Kingdom), weighted according to one of three schemes: proportion of GDP, equal weights, and share of equity market capitalization. In this section, we

[1] For the computation of Tobin's Q, it is essential to have total stock market capitalization. The World Bank provides these series for a large set of countries only starting from 1989.

report results for all three alternatives; in the rest of our analysis, we use the results for the GDP weighting as our benchmark for calibration and target moments.

In the interest of space, we describe the data sources in detail in Appendix A. All local macro variables are obtained from the Penn World Table and from the International Financial Statistics (IFS) dataset provided by the International Monetary Fund (IMF). The price-to-dividend (pd) ratios for each country are obtained from Kenneth French's and Robert Shiller's websites. All other financial variables are from IFS. Current account variables are obtained from two sources. US bilateral imports and exports with each remaining G7 country are obtained from the Direction of Trade Statistics (DOTS) dataset offered by the IMF. Bilateral trade variables are used to generate imports and exports of the US vis-$\grave{a}$-vis our aggregate RoW adopting one of the afore mentioned weighting schemes. For robustness, we also repeat our empirical investigation using total US imports and exports vis-$\grave{a}$-vis the remainder of the world, that is, including countries beyond the G7 group. Total net exports are from the Bureau of Economic Analysis (BEA). All data are annual.

Our balanced sample starts in 1973 and ends in 2006. This choice allows us to focus on a regime of flexible exchange rates (post–Bretton Wood period), characterized by substantial financial integration across all major industrialized countries (see inter alia Quinn (1997) and Obstfeld (1998)). We exclude recent years from our sample to prevent our results from being driven by the Great Recession. We conduct all our estimation exercises using one-year growth rates, as opposed to multiple-year growth rates, due to the loss of statistical power that would arise from the smaller sample size associated to increasing forecast horizon windows. We report the moment conditions associated with this exercise in Appendix B.

2.3 Response to shocks

Current account, consumption, and investments. We use the shocks ε_a and ε_z identified by the above methodology to estimate the parameters in the following equation involving the change in the US net exports-output ratio:[2]

$$\Delta\left(\frac{NX_t^{US}}{GDP_t}\right) = \beta_{NX,a}\cdot\left(\varepsilon_{a,t}^{US}-\varepsilon_{a,t}^{RoW}\right)+\beta_{NX,z}\cdot\left(\varepsilon_{z,t}^{US}-\varepsilon_{z,t}^{RoW}\right)+\xi_t. \tag{3}$$

We measure the net exports of the US versus the RoW in two ways. First, we use bilateral imports and exports between the US and each of the remaining G7 countries to construct a narrow measure of bilateral trade. Specifically, total US imports and exports are obtained as the sum of all US imports and all US exports to and from each of the remaining G7 countries. Second, we repeat our analysis using US imports and exports versus the remainder of the world, that is, the countries beyond the G7 group. We interpret the first set of results as a benchmark that closely matches our model specification, and the second set as a robustness check to further validate our results.

We complement the analysis of equation (3) by studying the relative response of consumption and investments across countries to shocks to the expected and unanticipated components of productivity growth. Specifically, we regress both investment growth and consumption growth differentials between the US and the RoW onto the spread of the two shocks that we identify with our econometric procedure:

$$\Delta I_t^{US}-\Delta I_t^{RoW} = \beta_{I,a}\cdot(\varepsilon_{a,t}^{US}-\epsilon_{a,t}^{RoW})+\beta_{I,z}\cdot(\varepsilon_{z,t}^{US}-\varepsilon_{z,t}^{RoW})+\xi_t^i \tag{4}$$

$$\Delta c_t^{US}-\Delta c_t^{RoW} = \beta_{c,a}\cdot(\varepsilon_{a,t}^{US}-\epsilon_{a,t}^{RoW})+\beta_{c,z}\cdot(\varepsilon_{z,t}^{US}-\varepsilon_{z,t}^{RoW})+\xi_t^i, \tag{5}$$

where ΔI_t^i and Δc_t^i denote the change in investments and log consumption at date t, in country $i\in\{US, RoW\}$, respectively.

In the first two columns of table 1 we report the estimates of the coefficients in equation (3), while in the last two columns we report the estimated coefficients of the regression specifications in equations (4) and (5). For all the equations, we report the results associated to the three aggregation methods for the RoW discussed

[2] We report the required moment conditions in Appendix B.

TABLE 1: Empirical Evidence

	NX *(Bilateral)*	***NX*** *(US Total)*	***I*** *(Investments)*	***c*** *(Consumption)*
Panel A: GDP Weighted				
$\beta_{j,a}$	-0.096^{***}	-0.204^{***}	5.147^{***}	0.930^{***}
	(0.020)	(0.052)	(0.190)	(0.045)
$\beta_{j,z}$	1.072^{**}	2.561^{**}	-25.146^{***}	-1.339^{**}
	(0.446)	(1.077)	(4.644)	(0.566)
Panel B: Equally Weighted				
$\beta_{j,a}$	-0.083^{***}	-0.179^{***}	4.649^{***}	0.842^{***}
	(0.025)	(0.068)	(0.230)	(0.054)
$\beta_{j,z}$	1.028^{**}	2.618^{**}	-24.211^{***}	-1.129^{*}
	(0.402)	(1.165)	(3.816)	(0.620)
Panel C: Market Cap Weighted				
$\beta_{j,a}$	-0.100^{***}	-0.225^{***}	5.197^{***}	0.820^{***}
	(0.028)	(0.045)	(0.170)	(0.055)
$\beta_{j,z}$	0.917^{**}	2.441^{**}	-23.971^{***}	-0.411
	(0.395)	(1.055)	(4.422)	(0.483)

Notes - In this table we report estimates for the response of bilateral net exports between the US and the RoW (column 1), total US net exports (column 2), and investment ($\Delta i - \Delta i^{*}$) and consumption ($\Delta c - \Delta c^{*}$) growth differentials between the US and the RoW (columns 3 and 4) regressed onto the relativeshocks to the unanticipated (ε_a) and expected (ε_z) components of productivity growth. The estimated coefficients $\beta_{j,a}$ and $\beta_{j,z}$, $\forall j \in \{NX, I, c\}$ correspond to the parameters in equations (3), (4), and (5). The RoW quantities are obtained by aggregating the remaining G7 countries using GDP shares (panel A), equal weights (panel B), and market capitalization shares (panel C). Standard errors are adjusted for heteroskedasticity. The superscripts ***, **, and * denote significance at the 1%, 5%, and 10% confidence level, respectively. Data sources are detailed in Appendix A. Our sample starts in 1973 and ends in 2006.

above. Each linear model in equations (3)–(5) is jointly estimated with the system of equations (1)-(2) for each country. This procedure ensures that the standard errors reported in table 1 are reflective of all the uncertainty associated to our estimation exercise.

We highlight three important results. First, the US net exports decline upon the arrival of positive US-specific shocks to the unanticipated component of productivity ($\beta_{NX,a} < 0$), whereas the opposite is true for relative US investment growth ($\beta_{I,a} > 0$). This means that when a country receives a positive shock to the unanticipated component of productivity, it experiences a net inflow of resources that are used to support domestic investment growth.[3] This result mirrors that documented by BKK, thus reinforcing the validity of our identification scheme.

Second, the arrival of positive shocks to the conditional expectation of productivity in a given country results in an outflow of resources ($\beta_{NX,z} > 0$), and a relative increase in investments abroad ($\beta_{I,z} < 0$). This response goes exactly in the opposite direction of that observed with respect to shocks to the unanticipated component of productivity. The sign of the response of NX is robust to focusing only on G7 countries or on a broader set of countries (columns 1 and 2 in table 1). Furthermore, in table B3 of the appendix, we report the share of total R^2 for the regression defined in equation (3) that is explained by the shocks to the expected component of productivity. Across all the weighting schemes that we use for the RoW aggregate, we document that these shocks explain a substantial amount of the variation in the net exports, ranging between 59% and 73% of the total R^2. Even though country-specific news shocks are small, they can be as important as the shocks to the unanticipated component in explaining the volatility of net exports.

Third, consumption behaves similarly to investment: it increases in response to a positive shock to the unanticipated component, but it declines with respect to a positive shock to the conditional expectation. These responses are robust to the alternative ways of aggregating the RoW countries, and they represent a key empirical result against which we will compare our model. More precisely, we include these regressions in the auxiliary model that we use for the estimation of our structural risk-sharing model because they impose important restrictions on the response of international macro variables to productivity shocks of different nature.

We repeat the analysis reported in table 1 by focusing on Net Exports of Investments (NXI) as opposed to total NX, and employing a different source of data for bilateral NX (Mitchell (2007a, b, c)). The results reported in table B2 of Appendix B.3 are consistent with those discussed in this section. In the next section, we show

[3] We have replicated this regression by aggregating the RoW according to total trade (import plus exports) shares. For our benchmark case in column 1 od table 1, we obtain $\beta_{NX,a} = -0.090$ (0.027) and $\beta_{NX,z} = 0.888$ (0.379). Numbers in parentheses are standard errors.

that in our frictionless BKK model with recursive preferences long-run growth news produce a significative short-run reallocation across countries, as in the data.

3 Recursive Preferences and Risk-Sharing Motives

Our study is the first to fully characterize international trade with Epstein and Zin (1989) preferences in a production economy with news shocks. For this reason, we start by introducing notation about preferences and then we focus on a two-period EZ-BKK model to provide intuition on the resulting risk-sharing motives.

Let $\widetilde{C}$ denote the consumption bundle of the home country. The home-country preferences over an infinite horizon are

$$U_t = \left[(1-\beta)\cdot \widetilde{C}_t^{1-1/\psi} + \beta E_t\left[U_{t+1}^{1-\gamma}\right]^{\frac{1-1/\psi}{1-\gamma}}\right]^{\frac{1}{1-1/\psi}}. \tag{6}$$

The preferences of the foreign country are defined in the same manner over the consumption bundle $\widetilde{C}_t^*$. The coefficients γ and ψ measure the relative risk aversion (RRA) and the intertemporal elasticity of substitution (IES), respectively. We assume that the two countries have the same RRA and IES, as well as the same subjective discount factor.

With these preferences, agents are risk averse in future utility as well as future consumption. The extent of such utility risk aversion depends on the preference for early resolution of uncertainty, measured by $\gamma - 1/\psi > 0$. This can be better highlighted by focusing on the ordinally equivalent transformation

$$V_t = \frac{U_t^{1-1/\psi}}{1-1/\psi}$$

and performing a second-order Taylor expansion about the conditional mean of $\log V_{t+1}$

to obtain

$$V_t \approx (1-\beta)\frac{\widetilde{C}_t^{1-1/\psi}}{1-1/\psi} + \beta E_t\left[V_{t+1}\right] - \frac{(\gamma-1/\psi)}{2}\beta Var_t\left[V_{t+1}\right]\kappa_t, \tag{7}$$

where $\kappa_t \equiv \frac{1}{E_t[(1-1/\psi)V_{t+1}]} > 0$. When $\gamma = 1/\psi$, the agent is utility-risk neutral and preferences collapse to the standard time-additive case. When the agent prefers early resolution of uncertainty, that is, $\gamma > 1/\psi$, uncertainty about continuation utility reduces welfare and generates an incentive to trade off future expected utility, $E_t\left[V_{t+1}\right]$, for future utility risk, $Var_t\left[V_{t+1}\right]$. This trade-off drives international consumption and investment flows, and it represents one of the most important elements of our analysis.

Furthermore, this trade-off is also present in the home stochastic discount factor,

$$M_{t+1} = \beta\left(\frac{\widetilde{C}_{t+1}}{\widetilde{C}_t}\right)^{-\frac{1}{\psi}}\left(\frac{U_{t+1}}{E_t\left[U_{t+1}^{1-\gamma}\right]^{\frac{1}{1-\gamma}}}\right)^{\frac{1}{\psi}-\gamma}, \tag{8}$$

as the second term captures aversion to continuation utility risk and is extremely sensitive to growth news (Bansal and Yaron (2004)).

Equation (7) is reported for explanatory purposes only. The rest of the analysis is conducted with the preference specification in equation (6). We note that when $\psi = 1$, preferences take the following form,

$$V_t = (1-\beta)\cdot\log\widetilde{C}_t + \frac{\beta}{1-\gamma}\log E_t\left[\exp\{V_{t+1}\cdot(1-\gamma)\}\right]. \tag{9}$$

When $\psi = 1$, if $\log V_t$ is normally distributed, equation (7) has the following exact counterpart:

$$V_t = (1-\beta)\cdot\log\widetilde{C}_t + \beta E_t\left[V_{t+1}\right] - \frac{(\gamma-1)}{2}\beta Var_t\left[V_{t+1}\right].$$

Since there is a one-to-one mapping between utility, U_t, and lifetime wealth, i.e., the value of a perpetual claim to consumption, the optimal risk-sharing scheme can also be interpreted in terms of mean-variance trade-off of wealth. For this reason, in what follows we will use the terms "wealth" and "continuation utility" interchangeably.

3.1 Recursive Risk-Sharing of News: Intuition

In this section, we present a two-period BKK model with recursive preferences. In order to provide a simple intuition on the capital reallocation motives induced by the interplay of recursive preferences and news shocks, we abstract away from short-run shocks. Our qualitative findings apply to the fully fledged EZ-BKK model introduced in the section 4.

Timing and information structure. The economy consists of three dates: $t = \{0, 1, 2\}$. At the end of the first period (time $t = 1$), agents receive news θ about the productivity that capital will have in the second period. Since θ does not alter productivity at time $t = 1$, it represents a pure news shock. For simplicity, no other shock materializes at $t = 1, 2$; hence all uncertainty is resolved at time $t = 1$.

Utility and technology. Let $\{X_t, Y_t\}$ and $\{X_t^*, Y_t^*\}$ denote the time t consumption of goods X and Y in the home and foreign countries, respectively. The consumption aggregates in the two countries are

$$C_t = X_t^{\lambda} \cdot Y_t^{(1-\lambda)}, \quad C_t^* = X_t^{*(1-\lambda)} \cdot Y_t^{*\lambda}. \tag{10}$$

We assume that the home (foreign) country produces good X (Y) so that $\lambda > 1/2$ introduces consumption home bias.

In order to get a closed-form solution, we assume that agents have unit IES $\psi = 1$, as in equation (9). Preferences can be written as

$$u_0 \quad = \quad (1-\beta)\log C_0^i + \frac{\beta}{1-\gamma}\log E_0[\exp\{u_1^i(1-\gamma)\}], \tag{11}$$

where we adopt the convention that lowercase letters denote logarithmic units. When $\gamma = 1$, we have the standard time-additive CRRA log case.[4] Since uncertainty is fully resolved when $t = 1$, $\log E_1[\exp\{(1-\gamma)u_2^i\}] = (1-\beta)(1-\gamma)\log C_2^i$, and hence we can write

$$u_1 = (1-\beta)\log C_1 + \beta(1-\beta)\log C_2.$$

A symmetric specification applies to the foreign country, for which the variables are indexed with an asterisk "*".

At time $t = 1$, total production is assumed to be fixed, like in a production economy where labor does not adjust and capital is predetermined. Since the size of output does not affect time $t = 1$ relative reallocation, we normalize total production to be 1. Output can be used for consumption or investment purposes, implying that the resource constraints at $t = 1$ are

$$1 = X_1 + X_1^* + I_{x,1} + I_{y,1}, \qquad 1 = Y_1 + Y_1^* + I_{x,1}^* + I_{y,1}^*. \tag{12}$$

From a home (foreign) country perspective, $I_{x,t}$ ($I_{y,t}^*$) measures real local investment, while $I_{y,t}$ ($I_{x,t}^*$) measures investment abroad. Even though capital stocks are country-specific, agents can trade both consumption and investment goods without any friction in every state of the world.

At time $t = 2$, domestic and foreign capital stocks are formed by combining domestic and foreign investments, which are characterized by the presence of investment home bias indexed by $\lambda_I \in (0,1)$,

$$G = I_{x,1}^{\lambda_I} I_{x,1}^{*1-\lambda_I}, \qquad G^* = I_{y,1}^{1-\lambda_I} I_{y,1}^{*\lambda_I}, \tag{13}$$

[4] Recursive preferences collapse to time-additive CRRA preferences when risk aversion is equal to the reciprocal of the IES. Since in this simplified model we are focusing on the case of unit IES, expected utility obtains for $\gamma = 1$.

and the resulting stochastic output is allocated to final consumption at $t = 2$:

$$
\begin{gathered}
e^{\theta} G(I_{x,1}, I^*_{x,1}) = X_2 + X^*_2, \qquad e^{-\theta} G^*(I_{y,1}, I^*_{y,1}) = Y_2 + Y^*_2, \\
\theta \sim iidN(0, \sigma).
\end{gathered}
\tag{14}
$$

To preserve the symmetric structure of the model, we assume that the same θ affects domestic and foreign productivity with opposite signs. In what follows, we show that the results depend only on the relative cross-country productivity (in this setting, $2 \cdot \theta$).

Time-0 Pareto problem. Since the time $t = 0$ consumption level plays no role for the future allocation, we set $C_0 = C^*_0 > 0$ to preserve symmetry without loss of generality. Before the arrival of the news shocks (i.e., at date $t = 0$), we assume that agents trade a complete set of θ-contingent securities to maximize their time $t = 0$ utility. As a result, the allocation can be recovered by solving the following Pareto problem:

$$
\max_{\left\{\{X_t, X^*_t, Y_t, Y^*_t\}_{t=1,2}, I_{x,1}, I_{y,1}, I^*_{x,1}, I^*_{y,1}\right\}} \mu_0 \cdot u_0 + (1 - \mu_0) \cdot u^*_0,
$$

subject to the constraints specified in equations (10)–(14). We assume a symmetric initial distribution of wealth, so that the ratio of the time-0 Pareto weights is one:

$$
S_0 \equiv \frac{\mu_0}{1 - \mu_0} = 1.
$$

Main results. We are interested in the implications of the model for the net exports upon the arrival of the news shock at $t = 1$. The optimality conditions for the allocation of goods X_1 and Y_1 are

$$
S_1(\theta) \frac{\partial \log C_1}{\partial X_1} = \frac{\partial \log C^*_1}{\partial X^*_1}, \qquad S_1(\theta) \frac{\partial \log C_1}{\partial Y_1} = \frac{\partial \log C^*_1}{\partial Y^*_1},
\tag{15}
$$

where $S_1(\theta)$ is the ratio of the pseudo-Pareto weights at $t = 1$, which takes the following recursive form:

$$S_1(\theta) = S_0 \cdot \frac{e^{u_1(1-\gamma)}}{E_0[e^{u_1(1-\gamma)}]} \Big/ \frac{e^{u_1^*(1-\gamma)}}{E_0[e^{u_1^*(1-\gamma)}]}. \tag{16}$$

Equation (15) establishes that the optimal allocation can be found as in a regular static problem, for a *given* value of S_1. Accordingly, the allocations satisfy the following conditions:

$$\frac{X_1}{X_1^*} = \frac{\alpha}{1-\alpha} S_1, \quad \frac{Y_1}{Y_1^*} = \frac{1-\alpha}{\alpha} S_1,$$

implying that when $S_1(\theta)$ declines, the home country consumes a smaller share of total resources. As shown in Appendix C.1, the following conditions hold as equilibrium outcomes:

$$\begin{aligned} \frac{NX_1^C}{X_1}(S_1 = 1) &= 0, \quad \frac{\partial \frac{NX_1^C}{X_1}}{\partial S_1}(S_1 = 1) = -\frac{1-\lambda}{\lambda} < 0 \\ \frac{NX_1^I}{I_{x,1}}(S_1 = 1) &= 0, \quad \frac{\partial \frac{NX_1^I}{I_{x,1}}}{\partial S_1}(S_1 = 1) = -\frac{1-\lambda_I}{\lambda_I}(2\lambda - 1) < 0 \quad \text{if} \quad \lambda > 1/2, \end{aligned} \tag{17}$$

where NX^C (NX^I) denotes the net exports of consumption (investment) goods of the home country. As a result, when there is consumption home bias, the direction of the net export flow depends solely on the adjustment of $S_1(\theta)$ with respect to the news θ. In Appendix C.1, we use a first-order approximation to show that

$$S_1(\theta) \approx \exp\left\{ \frac{(2\lambda - 1)(1-\gamma)}{1 - 2\lambda_u^s(1-\gamma)} 2\theta \right\}, \tag{18}$$

where $\lambda_u^s \equiv \frac{\partial u_1}{\partial \ln S_1} \geq 0$, i.e., the utility is increasing with the share of consumption.[5]

From equation (18) we obtain three important results. First, both consumption home bias ($\lambda \neq 1/2$) and preference for the resolution of uncertainty ($\gamma \neq 1$) are

[5] In Appendix C.1, we show that the assumption of consumption home bias, $\lambda > 1/2$, is sufficient (but not necessary) to guarantee that λ_u^s is positive. See equation (C17) and lemma 1.

essential for a reallocation ($S_1 \neq S_0$= 1). In the absence of consumption home bias, all shocks are aggregate shocks to a common single good, as in Anderson (2005). In this case, the marginal utilities of the two agents perfectly comove across states and there is no effect on S_1, that is, $S_1 = S_0 = 1$. The same result applies when agents care only about expected utility and do not price news ($\gamma = 1$).

Second, if agents dislike late resolution of uncertainty ($\gamma > 1$) and have consumption home bias ($\lambda > 1/2$), the ratio $\frac{(2\lambda-1)(1-\gamma)}{1-2\lambda_u^s(1-\gamma)}$ is negative. As a result, when the home country receives good news ($\theta > 0$), its pseudo-Pareto weight drops and more resources are allocated to the foreign country ($S_1 < S_0$). Furthermore, the domestic net exports become positive, consistent with equation (17). The intuition is as follows: under these parameter conditions $\frac{\partial u_1}{\partial \theta} > 0$, implying that high-$\theta$ states are associated to low marginal utility for the home country relative to the foreign country. In this case, it is optimal to shift resources toward the foreign country by letting the home country run a positive current account.

Third, if agents have home bias ($\lambda > 1/2$) but prefer late resolution of uncertainty ($\gamma < 1$), the news-driven reallocation implies a capital inflow toward the home country when $\theta > 0$, in contrast to the data. The same counterfactual result applies to the case of foreign bias ($\lambda < 1/2$) and significant preference for late resolution of uncertainty.

Summarizing, this setting clearly shows that when (i) agents like early resolution of uncertainty, and (ii) there is consumption home-bias, optimal risk-sharing of news shocks prescribes an increase in investment in the (ex-post) less productive country. In the next section, we document that this risk-sharing channel plays an important role in a BKK model with recursive preferences.

4 Infinite Horizon Model

We study an infinite horizon, two-country, two-good BKK economy with two main departures consisting of (i) the adoption of recursive preferences, and (ii) the introduction of news shocks. Since many of the elements of this model have been introduced in the previous section, we just highlight the additional features of the fully fledged BKK model. In Appendix C.2, we describe a generalized version of the model that encompasses all the cases studied in our manuscript, and we derive all the required optimality conditions. In what follows, we denote foreign variables with an asterisk and use lowercase letters for log-units, for example, $x_t = \log X_t$.

4.1 The economy

Consumption bundles and preferences. The consumption aggregates in the two countries are specified as in equation (10) and feature consumption home bias ($\lambda > 1/2$), a common assumption in the international macroeconomic literature.

We introduce endogenous labor supply by assuming that the domestic (foreign) consumption bundle, $\widetilde{C}$ ($\widetilde{C}^*$), embodies both consumption utility and labor disutility. This assumption is not crucial, as our main results on international capital flows may also be obtained with a fixed labor supply. Nevertheless, we introduce this assumption to document the generality of our approach.

Raffo (2008) shows that when a CES aggregator of consumption and leisure is used, the countercyclicality of the net export in the BKK model originates from extreme adjustments in the terms of trade. This finding is at odds with the data, where most of the action comes from adjustments in the quantity of imports. To avoid this problem, we follow Raffo (2008) and adopt Greenwood et al. (1988) (henceforth GHH) preferences

$$\tilde{C}_t = C_t - \varphi_t N_t^{1+\frac{1}{f}}, \quad \tilde{C}_t^* = C_t^* - \varphi_t^* N_t^{*1+\frac{1}{f}},$$

where N (N^*) denotes hours worked in the home (foreign) country. To guarantee balanced growth, we assume that φ_t (φ_t^*) is cointegrated with productivity A_t (A_t^*) as follows:

$$\begin{aligned}\log(\varphi_t/A_t) &:= \log\varphi + \mu(1-\hat{\theta}) + (\hat{\theta}-1)(\Delta a_t - \log(\varphi_{t-1}/A_{t-1}))\\ \log(\varphi_t^*/A_t^*) &:= \log\varphi + \mu(1-\hat{\theta}) + (\hat{\theta}-1)(\Delta a_t^* - \log(\varphi_{t-1}^*/A_{t-1}^*)),\end{aligned}$$

where Δa_t (Δa_t^*) denotes the growth rate of productivity in the home (foreign) country, and $\mu = E[\Delta a] = E[\Delta a^*]$. We set $\hat{\theta} = 0.10$ so that φ_t and φ_t^* mimic exogenous time trends. Preferences are specified over these consumption bundles as detailed in equation (6).

Productivity. We model the growth rate of productivity in the spirit of the long-run risk literature. Specifically, we introduce country-specific long-run productivity components, z and z^*, as in Croce (2014), and assume that the domestic and foreign productivity processes, A and A^*, are cointegrated (Rabanal et al. (2011), Colacito and Croce (2013)):

$$\begin{aligned}\Delta a_t &= \mu + z_{t-1} - \tau\cdot\log\frac{A_{t-1}}{A_{t-1}^*} + \varepsilon_{a,t} \\ \Delta a_t^* &= \mu + z_{t-1}^* + \tau\cdot\log\frac{A_{t-1}}{A_{t-1}^*} + \varepsilon_{a,t}^* \\ z_t &= \rho z_{t-1} + \varepsilon_{z,t} \\ z_t^* &= \rho z_{t-1}^* + \varepsilon_{z,t}^*,\end{aligned} \tag{19}$$

where $\varepsilon_{z,t}$ and $\varepsilon_{z,t}^*$ represent long-run shocks, whereas $\varepsilon_{a,t}$ and $\varepsilon_{a,t}^*$ represent short-run shocks. Shocks are jointly lognormally distributed:

$$\xi_t \equiv \begin{bmatrix} \varepsilon_{z,t} & \varepsilon_{z,t}^* & \varepsilon_{a,t} & \varepsilon_{a,t}^* \end{bmatrix} \sim \quad i.i.d. N(\mathbf{0}, \Sigma),$$

where

$$
\Sigma = \begin{bmatrix} (\sigma_z\sigma)^2 & \rho_{lrr}(\sigma_z\sigma)^2 & 0 & 0 \\ \rho_{lrr}(\sigma_z\sigma)^2 & (\sigma_z\sigma)^2 & 0 & 0 \\ 0 & 0 & \sigma^2 & \rho_{srr}\sigma^2 \\ 0 & 0 & \rho_{srr}\sigma^2 & \sigma^2 \end{bmatrix}.
$$

The parameter $\tau \in (0,1)$ is calibrated to a small number to generate moderate cointegration. Under this assumption, the productivity specification in equation (19) is consistent with that used in our empirical investigation (see equation (29)) and can be calibrated using productivity data for the US and the remaining G7 countries.

Vintage capital. We follow Ai et al. (2013) and introduce a capital accumulation friction obtained by aggregating overlapping generations of capital vintages. We choose this approach for two reasons. First, this friction creates a strong positive link between long-run news and the market value of capital, as in the data. Second, this friction increases the volatility of investment, in contrast to convex adjustment costs as in Jermann (1998). In what follows, we describe our assumptions for the home country. Similar conditions apply to the foreign country.

Production units created at time τ are called generation-τ production units and begin operation at time $\tau+1$. For $t \geq \tau+1$, each generation-τ production unit combines labor, n_t^τ, and a *fixed* amount $\overline{k}$ of generation-τ capital according to the following production function:

$$
x_t^\tau = (A_t^\tau n_t^\tau)^{1-\alpha}(\overline{k})^\alpha,
$$

where A_t^τ denotes the time t labor productivity level common to all the production units belonging to generation τ, and $\overline{k} = 1$ for simplicity. Fixing the size of capital at the production unit level enables us to have constant returns to scale at the aggregate level.

Let there be $(1-\delta_k)^{t-\tau-1}G_\tau$ units of generation-τ capital at time t, where δ_K captures depreciation. Since each firm must use exactly one unit of generation-τ capital there must be $(1-\delta_k)^{t-\tau-1}G_\tau$ production units of type τ. As a result, the total output of generation-τ production units at time t is given by $(1-\delta_k)^{t-\tau-1}G_\tau \cdot [(A_t^\tau n_t^\tau)^{1-\alpha}]$ and their total labor used is $(1-\delta_k)^{t-\tau-1}G_\tau n_t^\tau$. Assume that labor is freely mobile across plants and focus on the following static allocation problem

$$
\begin{aligned}
\max_{\{n_t^\tau\}_\tau} X_t^T \quad &= \quad \sum_{\tau=0}^{t-1}(1-\delta_k)^{t-\tau-1}G_\tau \cdot [(A_t^\tau n_t^\tau)^{1-\alpha}] \\
\text{s.t.} \quad & \\
& \quad \sum_{\tau=0}^{t-1}(1-\delta_k)^{t-\tau-1}G_\tau n_t^\tau \leq N_t,
\end{aligned}
\tag{20}
$$

where N_t is the total supply of labor at time t. At the optimum, the marginal product of each worker must be equated across all types of production units implying that:

$$
\frac{n_t^\tau}{n_t^0} = \left(\frac{A_t^\tau}{A_t^0}\right)^{\frac{1}{\alpha}-1}, \tag{21}
$$

that is, more labor is allocated to generation-τ technology as the productivity gap $\frac{A_t^\tau}{A_t^0}$ increases.

The productivity processes are specified as follows. First, we assume that the log growth rate of the productivity process for the initial generation ($\tau = 0$) of production units, Δa_{t+1}, is given by equation (19). Second, we impose that the growth rate of the productivity of production units of age $j = 0, 1, ..., t-1$ is given by

$$
\frac{A_{t+1}^{t-j}}{A_t^{t-j}} = e^{\mu+\phi_j(\Delta a_{t+1}-\mu)}. \tag{22}
$$

Under the above specification, production units of all generations have the same unconditional expected growth rate. We also set $A_t^t = A_t$ to ensure that new production units are on average as productive as older ones.[6] Heterogeneity hence is driven solely by differences in exposure to aggregate productivity risk, ϕ_j.

Working with COMPUSTAT annual data on the cross section of US firms, Ai et al.

[6]Generation-t production units are not active until period $t+1$; therefore, the level of A_t^t does not affect the total production of the economy in period t.

(2013) note that the growth rate of productivity of young vintages of capital has less exposure to aggregate productivity shocks compared to older vintages. To capture this empirical fact, they adopt a parsimonious specification of the ϕ_j function as follows:

$$\phi_j = \begin{cases} 0 & j = 0 \\ 1 & j = 1, 2, \cdots . \end{cases}$$

That is, new production units are not exposed to aggregate productivity shocks in the initial period of their life, and afterwards their exposure to aggregate productivity shocks is identical to that of all other existing generations.[7] In this setting, it is possible to measure production units of all generations in terms of their generation-0 equivalents. As shown in Appendix C.3, standard aggregation results (see, for example, Atkeson and Kehoe (2005)) apply to equations (20)–(21) and we can represent aggregate production, X_t^T, as:

$$X_t^T = K_t^{\alpha} \left(A_t N_t\right)^{1-\alpha},$$

in which the productivity-adjusted measure of tangible capital, K_t, takes the following simple form:

$$K_{t+1} = \left(1 - \delta_k\right) K_t + \varpi_{t+1} G_t, \quad t = 1, 2, \cdots , \tag{23}$$

and

$$\varpi_{t+1} := \left(\frac{A_{t+1}^t}{A_{t+1}}\right)^{\frac{1}{\alpha}-1} = e^{-\left(\frac{1}{\alpha}-1\right)(1-\phi_0)(\Delta a_{t+1}-\mu)} \quad \forall t.$$

This specification of productivity maintains tractability at the aggregate level and collapses to that of the standard BKK model when $\phi_0 = 1$ and G_t is specified as in

[7] In the data, the productivity process of younger firms has a higher idiosyncratic volatility than that of older firms. To capture this fact, generation-specific shocks should be included in equation (22). After solving the model with these additional shocks, however, we find only negligible differences in our results. We therefore choose not to include this additional source of shocks for parsimony.

equation (13). As in BKK, output can be used for consumption or investment:

$$
\begin{aligned}
X_t^T &= K_t^{\alpha}(A_t N_t)^{1-\alpha} = X_t + X_t^* + I_{x,t} + I_{y,t} \\
Y_t^T &= K_t^{*\alpha}(A_t^* N_t^*)^{1-\alpha} = Y_t^* + Y_t + I_{y,t}^* + I_{x,t}^*.
\end{aligned}
$$

In our baseline calibration, we set $\lambda_I = \lambda > 1/2$ to be consistent with BKK and to highlight the key role played by recursive preferences. As shown in our previous section, our main results on the net exports adjustment do not depend on λ_I. We relax this assumption when conducting sensitivity analysis in Appendix C.4.

4.2 Risk-sharing rules and asset prices

We assume that markets are complete both domestically and internationally, so the allocation of the competitive equilibrium can be found by solving the Pareto problem associated with our economy (see Appendix C.2). Prices can then be recovered using the planner's shadow valuations. Below we report the equilibrium conditions for consumption and investment.

Consumption allocations. The optimal allocation of the two goods devoted to consumption can be characterized using the following first-order necessary conditions:

$$
\begin{aligned}
S_t \cdot \frac{\partial C_t}{\partial X_t} \cdot \frac{1}{C_t} &= \frac{\partial C_t^*}{\partial X_t^*} \cdot \frac{1}{C_t^*} \\
S_t \cdot \frac{\partial C_t}{\partial Y_t} \cdot \frac{1}{C_t} &= \frac{\partial C_t^*}{\partial Y_t^*} \cdot \frac{1}{C_t^*},
\end{aligned} \tag{24}
$$

where S_t is the ratio of the pseudo-Pareto weight of the home and foreign countries, respectively. The dynamics of the additional state variable S_t are given by the process

$$
S_t = S_{t-1} \frac{M_t}{M_t^*} \frac{e^{\Delta c_t}}{e^{\Delta c_t^*}}, \tag{25}
$$

where M_t denotes the home stochastic discount factor expressed in units of the local consumption aggregate, C_t, and is equal to that described in equation (8).

Connection to our two-period model. As in equation (15), the system of equations (24) implies that a smaller share of resources available for consumption are allocated to the home country when S_t falls. According to equation (25), S_t declines when the home country marginal utility is relatively low, that is, in favorable states of the world.

We note two things. First, under both CRRA and EZ preferences, if γ is high enough this channel works in the opposite direction of the productivity channel with respect to short-run risk, as a bad short-run shock for home productivity produces an incentive to reallocate resources toward the home country.

Second, with consumption home bias ($\lambda > 1/2$) and preference for early resolution of uncertainty ($\gamma > 1/\psi$), bad long-run news for the home country immediately depresses wealth and increases the home marginal utility, thus generating an incentive to allocate resources toward the home country. With CRRA preferences, in contrast, marginal utilities are not directly affected by long-run productivity shocks ($\gamma = 1/\psi$) and long-run news has no direct impact on S_t. This is a generalization of the results discussed in the previous section for the special case of $\psi = 1$.

Asset prices and optimal investment. Since our asset pricing conditions are almost identical to those in the original BKK model, in what follows we mainly set notation and define relevant variables. Detailed and generalized computations are reported in Appendix C.2.

Let $Q_{k,t}$ ($Q^*_{k,t}$) denote the ex-dividend price of domestic (foreign) capital expressed in local output units. At the equilibrium, optimal within-country investment implies

$$\begin{aligned} \frac{1}{\lambda_I}\frac{I_{x,t}}{G_t} &= E_t\left[M^X_{t+1}\left(\alpha\frac{X^T_{t+1}}{K_{t+1}} + (1-\delta_k)Q_{k,t+1}\right)\varpi_{t+1}\right], \\ \frac{1}{\lambda_I}\frac{I^*_{y,t}}{G^*_t} &= E_t\left[M^Y_{t+1}\left(\alpha\frac{Y^T_{t+1}}{K^*_{t+1}} + (1-\delta_k)Q^*_{k,t+1}\right)\varpi^*_{t+1}\right], \end{aligned} \tag{26}$$

where the stochastic discount factors in local output units are specified as follows:

$$M_{t+1}^X = \frac{X_t}{X_{t+1}} \frac{C_{t+1}}{C_t} M_{t+1}, \qquad M_{t+1}^Y = \frac{Y_t^*}{Y_{t+1}^*} \frac{C_{t+1}^*}{C_t^*} M_{t+1}^*.$$

On the left-hand side of each equation in (26), we have the marginal rate of transformation of consumption into new domestic or foreign capital. This object measures the marginal cost of new capital paid with certainty at time t.

On the right-hand side of each equation, we have the expected present value of the future benefits of an extra unit of young vintage capital. This benefit takes into account the future productivity gap between old and new capital vintages realized at time $t+1$. Even though these optimality conditions are similar to those obtained with investment-specific shocks (Mandelman et al. (2011)), we note that our productivity gap processes are endogenously driven by aggregate short- and long-run shocks. These shocks induce a reallocation of labor across different vintages that adds further uncertainty in the investment decision. Our results extend the Ai et al. (2013) findings to settings in which new production units are created using both domestic and foreign capital goods. When $\phi_0 = 1$, all vintages of capital are homogeneous and the productivity wedges play no role ($\varpi_t = \varpi_t^* = 1 \quad \forall t$), as in BKK.

The returns of capital in the domestic and foreign countries are

$$R_{k,t+1} = \frac{\alpha \frac{X_{t+1}^T}{K_{t+1}} + (1-\delta_k) Q_{k,t+1}}{Q_{k,t}}, \quad R_{k,t+1}^* = \frac{\alpha \frac{Y_{t+1}^T}{K_{t+1}^*} + (1-\delta_k) Q_{k,t+1}^*}{Q_{k,t}^*}. \tag{27}$$

We denote the real risk-free rates as $R_{f,t}$ and $R_{f,t}$ and define excess returns as $R_t^{ex} = R_{k,t+1}/R_{f,t}$ and $R_t^{*ex} = R_{k,t+1}^*/R_{f,t}^*$.

Investments abroad are determined by the following no-arbitrage equations:

$$\begin{aligned} \frac{1}{1-\lambda_I} \frac{I_{y,t}}{G_t^*} &= E_t \left[M_{t+1}^X \left(\alpha \frac{Y_{t+1}^T}{K_{t+1}^*} + (1-\delta_k) Q_{k,t+1}^* \right) P_{t+1} \varpi_{t+1}^* \right], \\ \frac{1}{1-\lambda_I} \frac{I_{x,t}^*}{G_t} &= E_t \left[M_{t+1}^Y \left(\alpha \frac{X_{t+1}^T}{K_{t+1}} + (1-\delta_k) Q_{k,t+1} \right) / P_{t+1} \varpi_{t+1} \right]. \end{aligned} \tag{28}$$

which take into account exchange-rate risk through the terms of trade, P_t. Since markets are complete, the log growth of the real exchange rate in consumption units is also pinned down by the following restriction:

$$\Delta e_{t+1} = m_{t+1} - m^*_{t+1}.$$

4.3 Calibration and solution method

We illustrate the key mechanism of our model through a calibration exercise and summarize our annual parameter values in table 2. The top portion of the table refers to the parameters of the productivity process.

We set the average annual growth rate (μ) and the volatility of the short-run productivity shocks (σ) to replicate key properties of US real per-capita output over the 1929–2006 sample. The choice of this sample is standard in the long-run risk literature (see, among others, Bansal and Yaron (2004); Bansal et al. (2010); Colacito and Croce (2011, 2013); and Croce (2014)). More specifically, we target an average annual growth rate of 1.8% and a volatility of the growth rate of output of 3.5%. These numbers are broadly consistent with both US BEA data and with post–World War II data for the G7 countries. Furthermore, this calibration strategy enables us to replicate average consumption volatility for the G7 countries.

Our economy features a large correlation of long-run components (high ρ_{lrr}) and a low correlation of short-run shocks (low ρ_{srr}) across countries. This is consistent with the empirical findings in the international finance literature (see, among others, Bansal and Lundblad (2002); Colacito and Croce (2011, 2013); Lustig et al. (2011)) and in the international macro literature (Crucini et al. (2011)) about the existence of a world growth risk component that drives both asset prices and productivities. To keep the cross-country correlation of consumption growth across the US and RoW moderate, we set the short-run shocks correlation to zero.

In addition, we set $\tau = 0.007$, a value consistent with the findings in Rabanal et al.

TABLE 2: Calibrated Parameters

Productivity:						
	Av. Growth (μ)	Std(SR) (σ)	Std(LR) (σ_z)	LR-AR (ρ)	Corr(LR) (ρ_{lrr})	Corr(SR) (ρ_{srr})
Values	1.8%	3.85%	0.12	0.98	0.93	0.00

Technology:		
Capital Income Share (α)	Depreciation (δ_K)	Home Bias ($\lambda = \lambda_I$)
1/3	0.06	0.92

Preference Parameters:			
Labor Elasticity (f)	RRA (γ)	IES (Ψ)	Subj. Discount Rate (β)
1.5	10	1.2	0.972

Notes: This table reports the parameter values used for our benchmark annual calibration. Std(SR) and Std(LR) denote the standard deviation of the short- and long-run shocks, ϵ_a and $\epsilon_{z,t}$, respectively. LR-AR denotes the persistence of the productivity long-run components, as defined in equation (19). Corr(SR) and Corr(LR) refer to the cross-country correlation of short- and long-run shocks, respectively. The cointegration speed (τ) is set to 0.007. The smoothing parameter for the ϕ_t and ϕ_t^* processes ($\hat{\theta}$) is set to 0.10.

(2011).[8] In section 6, we validate this choice of parameters' values in the context of a formal estimation procedure.

On the technology side, the share of capital income, α, is calibrated as in BKK. Our capital depreciation rate, δ_K, is set to an annual 6% to prevent the steady-state investment-output share from being too large. We set the home-bias parameter to 92%. This value is higher than the 85% chosen by BKK because home bias is more pronounced within G7 countries. In Appendix C.4,we (i) discuss the sensitivity of our model with respect to this parameter, and (ii) introduce a larger degree of home bias in consumption than in investment (see, among others, Boileau (1999), Erceg et al. (2008), Cavallo and Landry (2010), and Engel and Wang (2011)). This keeps our model consistent with the fact that foreign consumption goods represent only 3%–5% of the US consumption bundle, whereas foreign investment goods represent about 15% of US aggregate investment in the post–Bretton Wood sample. Our main results are robust to this modification.

[8] An untabulated sensitivity analysis suggests that our results are robust to different values of this parameter.

The elasticity of substitution between labor and consumption is set to a value larger than 1 to be consistent with the evidence from aggregate data (among others, see Raffo (2008) and Gourio and Noual (2006)). The relative risk aversion is set to 10, a reasonable upper bound in the long-run risk literature.

In the context of an exchange economy with recursive risk-sharing, Colacito and Croce (2013) show that the IES should be set between 1 and 1.5. We set this parameter to the intermediate value of 1.2 and provide a sensitivity analysis with respect to this coefficient in section Appendix C.4. The subjective discount factor is chosen so as to keep the average annual risk-free rate close to 1% when possible.

Given these parameters, we use perturbation methods to solve our system of equations. We compute an approximation of the third order of our policy functions using the dynare++4.2.1 package. As documented in Colacito and Croce (2010, 2013), a third-order approximation is required to capture endogenous time-varying volatility due to the adjustments of the pseudo-Pareto weights. All variables included in our dynare++ code are expressed in log units.

5 Model Results

In this section, we present our main model-based results by proceeding in steps. First, we show that with time-additive preferences our results on international capital flows are an anomaly. Second, we document by means of impulse response functions that the introduction of recursive preferences in an otherwise standard BKK model (i.e., EZ-BKK) is able to rationalize our empirical findings. In order to show that our main results depend only on recursive preferences, we initially focus on the economy without vintage capital ($\phi_0 = 1$). In the last step, we show that our full model may be a benchmark for future research in production-based international macro-finance.

5.1 International capital flows and risk-sharing

A country is a net receiver or supplier of resources depending on its total net exports position (*NX*). This variable is subject to two effects potentially working in opposite directions.

On the one hand, positive productivity news generates an incentive to receive investment goods, that is, to have negative net exports of capital goods, $NXI_t = I_{y,t} - P_t I^*_{x,t}$. We refer to this effect as the productivity channel. On the other hand, depending on the extent of risk aversion, the risk-sharing motive may prescribe the exact opposite effect for the net flow of consumption goods, $NX_t - NXI_t = X^*_t - P_t Y_t$. If the risk aversion is strong enough, S_t may decline and consumption goods may be shipped abroad.

In order to study the productivity and risk-sharing channels, we report the responses of key international variables with respect to positive short- and long-run shocks in figure 1. We perform this exercise for both our EZ-BKK model and the standard BKK model with time-additive preferences. For the BKK setting, the relative risk aversion coefficient, γ, is set equal either to 10 or to $1/\Psi = 0.83$. These values are from our benchmark calibration with recursive preferences.

CRRA preferences and short-run shocks: the mechanism. Given our calibration, the response of the growth rate of the consumption bundle, $\Delta\tilde{c}$, to short-run shocks is quantitatively similar to that of the consumption aggregate, Δc. As a result, with time-additive preferences, the risk-sharing dynamics defined in equation (25) can be expressed as

$$\log \frac{S_t}{S_{t-1}} \approx (1-\gamma)(\Delta c_t - \Delta c^*_t),$$

and this implies that, when $\gamma > 1$, relative good news for domestic consumption growth generates an incentive to reallocate consumption goods abroad ($NX_t - NXI_t > 0$). The higher the risk aversion, the stronger this channel.

This is why when $\gamma = 10$, the realization of a positive short-run shock to the home

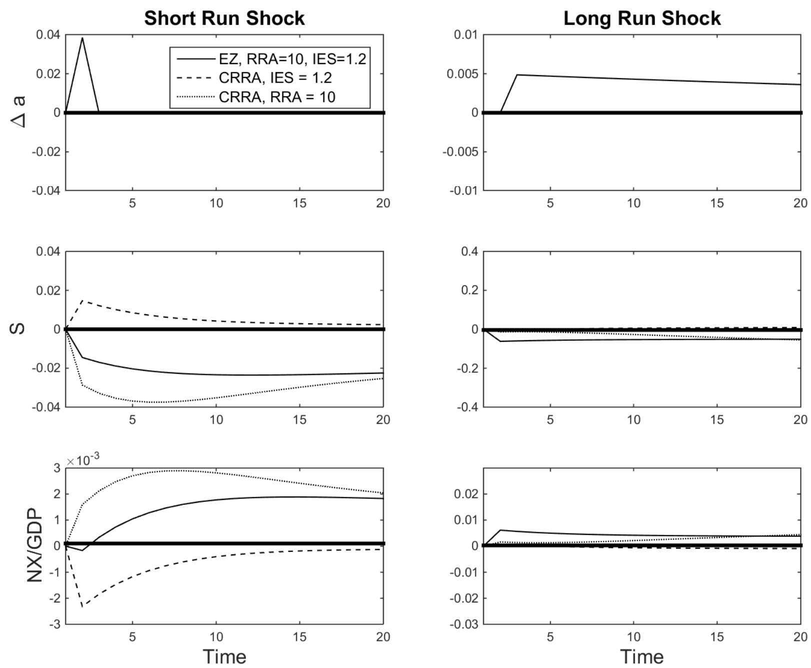

FIG. 1. Trading motives with and without EZ preferences. This figure shows annual deviations from the steady state. Both the ratio of the pseudo-Pareto weights, S, and productivity growth, Δa, are expressed in log units. NX/GDP denotes total net exports as a share of output. All the parameters are calibrated to the values reported in table 2 and all capital vintages are homogeneous ($\phi_0 = 1$). When time-additive preferences are employed, the RRA coefficient is set equal to either γ or $1/\psi$. Shocks to the home-country productivity, ϵ_a and ϵ_x, materialize at time 2 and are not orthogonalized by their international correlations, ρ_{srr} and ρ_{lrr}, respectively. The short-run (long-run) shock is assumed to affect only the home country and has a magnitude σ (σ_x).

country produces a counterfactual outflow of resources toward the foreign country (left column, dotted lines). At the equilibrium, home consumption growth immediately increases, and the risk-sharing motive is strong enough to overcome the productivity channel, that is, the positive net exports of consumption goods of the home country are greater than the net inflow of investment goods.

As the relative risk aversion declines, the productivity channel dominates, and the net exports become countercyclical as in the case of the original BKK analysis. In the case of $\gamma < 1$, the risk-sharing channel ends up amplifying the productivity channel: total net exports decline sharply because the home country becomes a net receiver of both consumption and investment goods.

CRRA preferences and long-run news: the anomaly. In our data, positive long-run news produces an immediate and sizeable increase in net exports. Time-additive preferences cannot reproduce this finding (right column of figure 1, second and third panels). Since the marginal utility of each agent depends only on current short-run consumption growth, news about future growth is not priced. By definition, long-run news produces no immediate change in current productivity differentials. Hence there is no reason to strongly alter S, NX, or NXI upon the arrival of long-run news, consistent with our analytical findings reported in section 3.1.

Over time, as news turns into realized short-run productivity gain differentials, the share of resources, S_t, adjusts. When $\gamma = 10$, the risk-sharing channel motive is strong enough to eventually dominate the productivity channel, as in the case of the short-run shocks. According to our calibration, the net exports improve with a delay of 8 years, a result inconsistent with our findings. When $\gamma < 1$, the response of the net exports is less delayed, but it goes in the wrong direction.

In principle, we could also shorten the delayed response of the net exports by setting γ well above 10. However, this would come at the cost of making the net exports positively correlated with short-run shocks and output growth. Such a result would be even less appealing, as the countercyclicality of the net exports is a well-established empirical fact. Given these considerations, our findings represent a non-trivial anomaly in the context of a classical BKK setting.[9]

Resolving the anomaly: EZ preferences. With recursive preferences, long-run news immediately and significantly affects the marginal utility of our agents through the continuation utility (wealth) channel, as captured in equation (8). Thanks to the presence of home bias and preference for early resolution of uncertainty, positive long-run news for the home country produces a more pronounced drop in the home

[9]We did not use Cobb-Douglas preferences between leisure and consumption, because even if it could generate a wealth effect consistent with the empirical response of the net exports, the Raffo (2009)'s critique about the terms of trade contribution to the volatility of the net exports would still be unresolved.

marginal utility. As $m_t - m_t^*$ declines, S_t falls substantially and the risk-sharing motive dominates the productivity channel, as suggested by our derivations in section 3.1. A greater share of both consumption and investment goods is transferred to the foreign country, consistent with the data.[10]

With respect to short-run shocks, in contrast, the productivity channel dominates the risk-sharing motive. When positive short-run shocks materialize, both NX and NXI deteriorate, as in a standard BKK model. Even though short-run shocks are more volatile and less correlated across countries than long-run news, their final impact on the risk-sharing motive is limited because their half-life is too short to significantly alter the continuation utility of our agents.[11]

5.2 Quantitative performance

In this section, we compare the standard BKK model to our EZ-BKK model on several quantitative dimensions. The relevance of this exercise is twofold. First, we show that the predictions of our EZ-BKK model are quantitatively close to our empirical results for net exports. Second, we show that our model inherits most of the successes of the standard BKK model as well as some of its limitations.

Domestic moments. In the top panel of table 3, we report the set of moments which are commonly analyzed in the one-country production-based asset pricing literature. Our model reproduces the volatility of both consumption and investment growth relative to that of output, whereas the volatility of labor is slightly lower than the estimated range in the data. This is actually a common limitation within the standard BKK model and, more broadly, within the production-based literature.

On the asset-pricing side, we note that the BKK model with high risk aversion is able to generate an equity premium of 0.42%. This result is entirely driven by short-

[10] Simultaneously, the real exchange rate depreciates. Focusing on the ten countries with the most actively traded currencies, Colacito et al. (2017) provide evidence that real exchange rates depreciate in response to positive news for long-run growth.

[11] Under incomplete markets, wealth does not adjust in the same state-contingent way and hence the reallocation that we document cannot be replicated to the same extent.

TABLE 3: Main Moments

Panel A: Domestic Moments	Vol. Relative to GDP			Asset Prices		Correlation$(\Delta\cdot,\Delta\cdot)$				ACF(1)
	Δn	Δc	Δi	E$[r_f]$(%)	E$[r^{ex}]$(%)	(c,i)	(c,n)	$(\frac{NX}{X^T},x^T)$	$(\frac{NXI}{X^T},x^T)$	$\frac{NX}{X^T}$
Data:	0.74	0.65	2.36	1.32	4.58	0.69	0.82	-0.36	-0.52	0.88
	(0.08)	(0.06)	(0.26)	(0.64)	(2.15)	(0.07)	(0.03)	(0.13)	(0.13)	(0.08)
BKK (RRA=1/1.2)	0.51	0.72	2.39	4.53	0.01	0.92	0.90	-0.66	-0.66	0.67
BKK (RRA=10)	0.46	0.84	4.12	16.63	0.42	0.36	0.86	0.55	-0.56	0.92
EZ-BKK	0.49	0.61	2.53	1.99	3.26	0.83	0.84	-0.24	-0.58	0.83

Panel B: International Moments	$\rho_h=$ corr$(\Delta h,\Delta h^*)$				StD$(\cdot)$(%)		Sensitivity to News			
	ρ_c	$\rho_{x^T}-\rho_c$	ρ_i	ρ_n	Δe	NX/X^T	β^{NX}_{SR}	β^{NX}_{LR}	R^2_{SR}/R^2	R^2_{LR}/R^2
Data:	0.37	0.15	0.33	0.53	5.93	0.56				
	(0.11)	(0.09)	(0.17)	(0.11)	(0.77)	(0.08)				
BKK (RRA=1/1.2)	0.12	0.06	0.05	0.09	1.82	0.47	-0.06	0.19	0.99	0.01
BKK (RRA=10)	0.46	-0.34	0.65	0.40	6.16	0.70	0.04	0.33	0.91	0.09
EZ-BKK	0.29	-0.20	0.27	0.21	3.99	0.50	-0.01	1.27	0.12	0.88

Notes: Empirical moments are computed using annual data from 1973 to 2006 for the US and the RoW aggregate. All data sources are discussed in section 2 and Appendix A. Numbers in parentheses are Newey-West adjusted standard errors. Excess returns are levered as in Garca-Feijo and Jorgensen (2010). For the EZ-BKK model, all the parameters are calibrated as in table 2 and capital vintages are heterogeneous ($\phi_0 = 0$). When time-additive preferences are employed, the risk-aversion coefficient is denoted as RRA. The entries for the models are obtained by repetitions of small-sample simulations. Lowercase letters denote log units. NX and NXI denote total net exports and net exports of capital goods only, respectively. The share of total R^2 of the predictive regressions that is accounted for by the long-run (short-run) shocks is denoted by R^2_{LR}/R^2 (R^2_{SR}/R^2).

run risk, as long-run shocks have no significant impact on excess returns (figure 2, bottom two panels). In EZ-BKK, in contrast, good long-run news produces positive excess returns. In the presence of heterogeneous capital vintages, this response is quantitatively sizeable (figure 2, bottom two panels) and, as a result, our equity premium is as high as 3.26%.

In terms of domestic comovements, all models produce a correlation for consumption and labor close to the data. All models reproduce the negative correlation between GDP and the US net exports of investment goods. The correlation between output and total net exports is counterfactually positive only in the BKK model with RRA set to 10. As previously documented, the risk-sharing motive dominates the productivity channel in this setting, thus making the response of net exports of consumption goods to short-run shocks strongly positive. Our EZ-BKK setting, instead, goes in the direction of replicating these negative correlations across both total net exports and net exports of investment goods. Furthermore, the EZ-BKK setting repli-

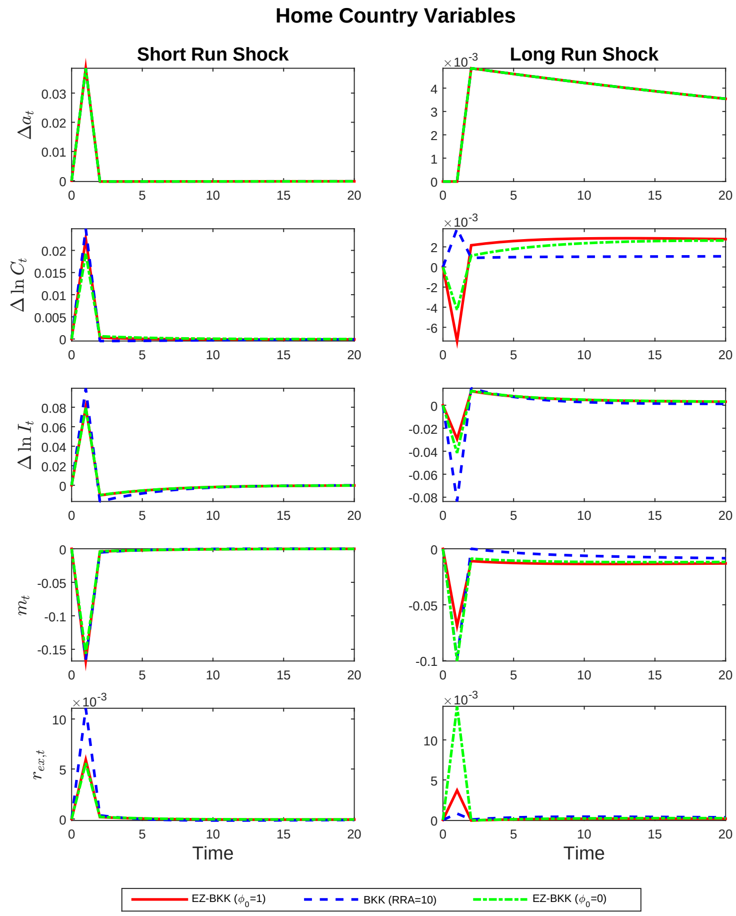

FIG. 2. Domestic comovements. This figure shows annual log deviations from the steady state. All the parameters are calibrated to the values reported in table 2. When time-additive preferences are employed, the RRA coefficient is set to 10. When $\phi_0 = 0$ ($\phi_0 = 1$) capital vintages are heterogeneous (homogeneous). Shocks to the home-country productivity, ϵ_a and ϵ_x, materialize at time 1 and are not orthogonalized by their respective international correlations, ρ_{srr} and ρ_{lrr}. The short-run (long-run) shock is assumed to affect only the home country and has a magnitude σ (σ_x).

cates the high autocorrelation of the net exports as a share of output, a result difficult to obtain in a BKK model with low risk aversion.

For both the EZ-BKK model and the BKK model with low risk aversion, the contemporaneous correlation of consumption and investment is close to the upper bound of our estimated confidence interval. The BKK model with high risk aversion, in contrast, predicts an excessively low correlation. Indeed, when $\gamma > 1$ the income effect dominates the substitution effect and the home country responds to positive long-run news by consuming more and investing less (figure 2, right panels).[12] This channel creates a negative comovement that lowers corr($\Delta i, \Delta c$).

In the EZ-BKK model, however, consumption and investment move in the same direction with respect to both short- and long-run shocks. Specifically, the home country finds it optimal to reduce both domestic consumption and investment in order to ship more resources abroad (the risk-sharing channel).

International moments. As shown in panel B of table 3, both the EZ-BKK and the standard BKK models feature similar international moments that are broadly aligned with the data. There is, however, one crucial difference. By denoting as β_{SR}^{NX} and β_{LR}^{NX} the estimated coefficients of a regression of NX on the simulated spreads of long-run shocks and short-run shocks, we note that only our EZ-BKK model predicts that a large share of variance of the net exports is due to long-run news. As a result, this is the only that produces sizeable responses of NX to long-run news ($\beta_{LR}^{NX} = 1.24$).[13]

We note that a standard BKK setting with low risk aversion fails to replicate the data along several dimensions. As an example, the quantity anomaly is resolved only because the cross-country correlations of consumption and investment are excessively low.[14]

The role of vintage capital. In figure 2, we report impulse responses to compare the predictions of our EZ-BKK model with those of our model featuring our vintage capital friction. Figure 2 confirms the three main findings obtained by Ai et al. (2013) in a one-country production economy. First, vintage capital leaves the responses unaltered with respect to short-run growth shocks, as these shocks are $i.i.d.$ and hence do not alter the expected relative productivity gap between young and old investments.

[12] In the BKK setting with $\gamma = 10$, there is no significant reallocation of resources across countries (figure 1). Hence the aforementioned response of both consumption and investment is fully consistent with that obtained in a one-country economy.

[13] Note that β_{LR}^{NX} (β_{SR}^{NX}) is obtained using the actual simulated long-run (short-run) shocks and hence it cannot be directly compared to the $\beta_{NX,z}$ ($\beta_{NX,a}$) parameter estimated in section 2.

[14] The full resolution of the quantity anomaly is beyond the scope of this study.

Second, the relative productivity gap across capital vintages produces more pronounced reactions of investment, making its growth rate volatile, as in the data. It is easier to interpret this response if expressed in terms of the level of the investment-output share. Upon the realization of the shock, it is optimal to postpone investment in young capital vintages, because they feature a negative productivity gap relative to old capital. At the equilibrium, the investment-output share immediately falls. Subsequently, the investment share slowly recovers (the investment growth rate is positive from period 2 onward), as the incentive to invest in new capital vintages becomes stronger.

Third, since the investment decision has to be made before the productivity growth gap across capital vintages is known, also the price of capital, Q_t, fluctuates more upon the arrival of shocks, and especially so for long-run news. More severe fluctuations in the value of capital generate more volatile capital excess returns. At the equilibrium, the covariance with the stochastic discount factor becomes more negative, implying a positive and sizeable long-run risk–driven risk premium.

As a result, the introduction of vintage capital is able to simultaneously produce more volatile investment, a high equity premium, and a slightly lower risk-free rate average (second column of table 4, panel A). This friction also enhances the quantitative role of short-run shocks for international trade, and hence it makes the net exports more countercyclical, consistent with our empirical confidence interval.[15]

In panel B of table 4, we assess the validity of our empirical approach in the context of our benchmark calibration. Under the setting with homogenous capital vintages ($\phi_0 = 1$), the absence of a capital accumulation friction renders Tobin's Q (denoted as q in table 4) and the long-run component (denoted as z in table 4) poorly correlated. As a result, when we run our auxiliary regression (1) on simulated data we are unable to detect the long-run component. Short- and long-run shocks are not properly disentangled, and the response of consumption, investment, and net exports implied

[15] We compare all moments produced by the EZ-BKK model with and without heterogenous capital vintages in table C2 of the appendix.

TABLE 4: The Role of Vintage Capital

	$\phi_0 = 1$	$\phi_0 = 0$	Data
Panel A: Main Moments of Interest			
StDev(I)/Stdev(X)	2.24	2.53	2.36 (0.26)
E[r^{ex}](%)	0.11	3.26	4.58 (2.15)
E[r_f](%)	2.31	1.99	1.32 (0.64)
corr($\Delta \frac{NX}{X^T}, \Delta x^T$)	-0.16	-0.24	-0.36 (0.13)
Panel B: Auxiliary Regressions			
corr(z, q)	0.06	0.93	
$\beta_{NX,a}$	-0.11	-0.03	-0.10 (0.02)
$\beta_{NX,z}$	-3.72	0.61	1.07 (0.45)
R^2_{LR}/R^2	0.97	0.84	0.60 (0.24)
$\beta_{c,a}$	0.69	0.37	0.93 (0.05)
$\beta_{c,z}$	9.38	-1.21	-1.34 (0.57)
$\beta_{I,a}$	3.31	1.24	5.15 (0.19)
$\beta_{I,z}$	104.13	-17.95	-25.15 (4.64)

Notes: Empirical moments are computed using annual data from 1973 to 2006. All data sources are discussed in section 2 and Appendix A. All the variables are defined as in table 3. In addition, the table also reports the correlation between Tobin's Q and long-run risk, $corr(z, q)$, and the elasticities defined in equations (4)–(5). Numbers in parentheses are Newey-West adjusted standard errors. Excess returns are levered as in Garca-Feijo and Jorgensen (2010). All the parameters are calibrated as in table 2. When $\phi_0 = 0$ ($\phi_0 = 1$), the model features heterogeneous (homogeneous) capital vintages. The entries for the models are obtained by repetitions of small-sample simulations. Lowercase letters denote log units.

by equations (3)–(5) is simply counterfactual.

As soon as we introduce the Ai et al. (2013) capital accumulation friction, our production economy resembles the endowment economy of Bansal and Yaron (2004) in which the market value of the tree per unit of endowment is a good proxy of the long-run component. As documented in the the column labeled "$\phi_0 = 0$" of table 4, the correlation between z and q is 93%, and the auxiliary regressions defined by equations (3)–(5) deliver sensitivities to news shocks that are reasonably close to our empirical point estimates and well within our confidence intervals. As in the data, growth news shocks play a significant role in explaining the fluctuations of net exports and produce a relative R^2 larger than 50% (see section 2.3).

Final remarks. To summarize, our EZ-BKK model without vintage capital is able to replicate key features of NX in connection with the arrival of long-run growth news, but it is subject to a few limitations: the countercyclicality of the net exports is not as strong as in the data; the average risk premium is almost zero; consumption growth rates are more correlated than output growth rates across countries, as in the standard BKK setting, and the absence of variation in Tobin's Q prevents asset prices from being highly correlated with the long-run components. On the other hand, our EZ-BKK model with vintage capital produces results that are consistent with both our empirical estimates and common international financial and business-cycle moments. We consider this result to represent significant progress in the international macro-finance literature.

In the next section, we validate further our results through a formal estimation procedure.

6 Estimation

We estimate the parameters of the productivity process in the two countries by adopting an indirect inference approach. This methodology relies on an auxiliary model, which is useful because it is easy to estimate and it captures the essential mechanisms of the model, that is, the differential response of net exports, investments, and consumption to shocks to the expected and unanticipated component of productivity. The methodology that we adopt is based on Gourieroux et al. (1993). In what follows we discuss the main steps of our analysis, and provide all the details in appendix Appendix D.

Structural parameters. We estimate the vector of structural parameters of the economic model:

$$\theta = \{\rho, \sigma_z, \rho_{lrr}, \rho_{srr}, \tau\}',$$

which determines the joint evolution of productivity in the two countries:

$$\begin{aligned} \Delta a_t^{US} &= z_{t-1}^{US} - \tau \left(a_{t-1}^{US} - a_{t-1}^{RoW} \right) + \sigma \varepsilon_{a,t}^{US}, \\ \Delta a_t^{RoW} &= z_{t-1}^{RoW} + \tau \left(a_{t-1}^{US} - a_{t-1}^{RoW} \right) + \sigma \varepsilon_{a,t}^{RoW}, \\ z_t^i &= \rho \cdot z_{t-1}^i + \sigma_z \cdot \sigma \cdot \varepsilon_{z,t}^i, \qquad \forall i \in \{US, RoW\}. \end{aligned} \tag{29}$$

All shocks are distributed as standard normals and the two parameters ρ_{lrr} and ρ_{srr} denote the international correlations of the shocks

$$\rho_{lrr} = E\left[\varepsilon_{z,t}^{US} \cdot \varepsilon_{z,t}^{RoW}\right], \quad \rho_{srr} = E\left[\varepsilon_{a,t}^{US} \cdot \varepsilon_{a,t}^{RoW}\right].$$

We fix all the other parameters to our calibrated values to reduce the dimensionality of the coefficient space. Capital vintages are heterogenous as in our benchmark model specification.

The literature has documented the difficulty of providing direct empirical evidence for productivity processes of the form specified in equation (29). Aguiar and Gopinath (2007) show that disentangling permanent and transitory components using empirical measures of the Solow residuals produces results that are both sensitive to the chosen specification and imprecisely estimated in short samples. Colacito and Croce (2011) find that for time series of less than 50 observations and a correlation of the country-specific predictive components smaller than 1, the long-run risks cannot be identified using the Kalman filter. These findings motivate our decision to use an indirect inference approach to estimate the structural parameters governing the dynamics of productivity.

Auxiliary Parameters. Let y_t denote the vector of observations

$$y_t = \left[\Delta a_t^{US}, \Delta a_t^{RoW}, pd_t^{US}, pd_t^{RoW}, \Delta\left(\frac{NX_t^{US}}{GDP_t}\right), \left(\Delta I_t^{US} - \Delta I_t^{RoW}\right), \left(\Delta c_t^{US} - \Delta c_t^{RoW}\right)\right]',$$

TABLE 5: Indirect Inference Estimates

Structural	ρ	σ_z	ρ_{srr}	ρ_{lrr}	τ
Estimates	0.98	0.08	0.27	0.97	0.02
(S.E.)	(0.00)	(0.02)	(0.25)	(0.01)	(0.02)

Auxiliary	$\beta_{NX,a}$	$\beta_{NX,z}$	$\beta_{I,a}$	$\beta_{I,z}$	$\beta_{c,a}$	$\beta_{c,z}$
Model	-0.39	0.87	2.04	-21.95	0.44	-0.31
Data	-0.08	0.74	5.16	-22.05	0.91	-0.66

Notes. The top portion of this table reports the estimates of our structural parameters with their associated standard errors in parenthesis. The bottom portion of the table reports the auxiliary coefficients of the regressions in equations (3), (4), and (5) obtained both from actual data and from data simulated from the estimated structural model.

and let $Y_T := (y_1, ..., y_T)$. We introduce a criterion which depends on Y_T and on the vector of auxiliary parameters:

$$\phi = \{\beta_a, \varsigma_a, \varsigma_z, \varrho, \varrho_a, \varrho_z, \beta_{NX,a}, \beta_{NX,z}, \beta_{I,a}, \beta_{I,z}, \beta_{c,a}, \beta_{c,z}\}'.$$

The vector ϕ is estimated by minimizing the norm of a vector of moment conditions based on the auxiliary regressions in equations (1)-(5) via GMM. We report the analytical form of the moment conditions in Appendix D.

Estimation and Results. We obtain an indirect inference estimator of θ as the solution of a minimum distance problem:

$$\min_{\theta} \Lambda\left(\theta\right) = \min_{\theta} \left[\hat{\phi}_T - \bar{\phi}_h(\theta)\right]' \cdot \left[\hat{\phi}_T - \bar{\phi}_h(\theta)\right],$$

where $\hat{\phi}_T$ and $\bar{\phi}_h(\theta)$ are the estimates of the parameters of the auxiliary model obtained from actual data and from data simulated conditional on the vector of structural parameter θ, respectively.

The results reported in table 5 are obtained using simulated Tobin's Q as the predictive variable of the simulated growth rate of productivity in each country. In addition, the Rest of the World aggregate in the data is obtained by weighting the remaining G-6 countries by their relative GDP shares. In Appendix D, we document

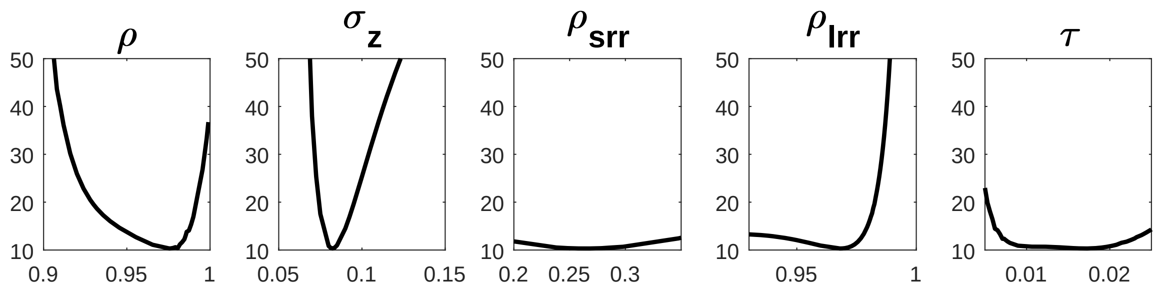

FIG. 3. Objective function of the indirect inference estimator. This figure shows the objective function of the indirect inference estimator (Λ) against each of the structural parameters of the vector θ in a neighborhood of the estimated values reported in table 5.

that when we introduce a redundant cash flow process in our model and use the associated equilibrium price-dividend ratio as predictor, our results continue to hold. Our results are also robust to weighting the RoW countries equally and by shares of market capitalization.

We report our estimates of the structural parameters in the vector θ in the top panel of table 5. Our most important findings are (i) the tight identification of the parameters governing the transition dynamics of the long-run risk processes (ρ, σ_z, and ρ_{lrr}), and (ii) the weak identification of the correlation of the short-run shocks (ρ_{srr}) and of the cointegrating term (τ). These numbers are in line with those that we adopted in our calibration exercises in the previous sections.

These findings are further reinforced when looking at figure 3. In each plot of this figure, we show the objective function of the indirect inference estimator (Λ) against each element of the vector of structural parameters (θ) in a neighborhood of the point estimates reported in table 5. The objective function becomes very steep as soon as we move away from the point estimates of ρ, σ_z, and ρ_{lrr}, while it remains relatively flat for ρ_{srr} and τ.

The bottom panel of table 5 and figure 4 shed further light on the role of the auxiliary regressions of net exports, investments, and consumption. Specifically, the bottom panel of table 5 shows that at the point estimates of the structural parameters,these auxiliary parameters are always very close to the estimates obtained from actual data. This statement is particularly true for the response of net exports, investments, and consumption to the spread of the shocks to the predictive components of the productivity growth rates.

We further investigate this claim in figure 4. In each panel of this figure, we report the estimates of the coefficients $\beta_{NX,z}$, $\beta_{I,z}$, and $\beta_{c,z}$ in the auxiliary regressions, as we vary the structural parameters that govern the dynamics of the long-run risk processes in the structural model. Inspection of each panel suggests that these auxiliary regressions impose very tight identifying restrictions on these specific structural parameters of interest. Furthermore, we note that the largest increase in the distances between the parameters $\beta_{NX,z}$, $\beta_{I,z}$, and $\beta_{c,z}$ in the model and in the data occurs when the relevance of the long-run risk processes is diminished, that is, when ρ and σ_z get smaller and when ρ_{lrr} gets closer to 1. Additionally, the estimates of this structural estimation confirm that the calibration that we adopted in the context of our recursive risk-sharing mechanism is empirically plausible.

7 Concluding Remarks

We provide novel empirical evidence for G7 countries regarding the effects of international long-term productivity news on international capital flows. In contrast to short-run growth news, positive long-run growth news produces an outflow of resources, that is, an increase in net exports, which results in a relatively higher level of investment abroad.

Through the lens of a standard BKK model with time-additive preferences, our empirical facts are shown to be an anomaly. We then investigate the effect of international long-term growth risk on capital flows in a BKK economy featuring a frictionless recursive risk-sharing scheme based on Epstein and Zin (1989) preferences. This modification alone is able to replicate our empirical findings.

In a second step, we enrich the BKK production structure to capture relevant empirical evidence on capital accumulation. By adding heterogeneous productivity

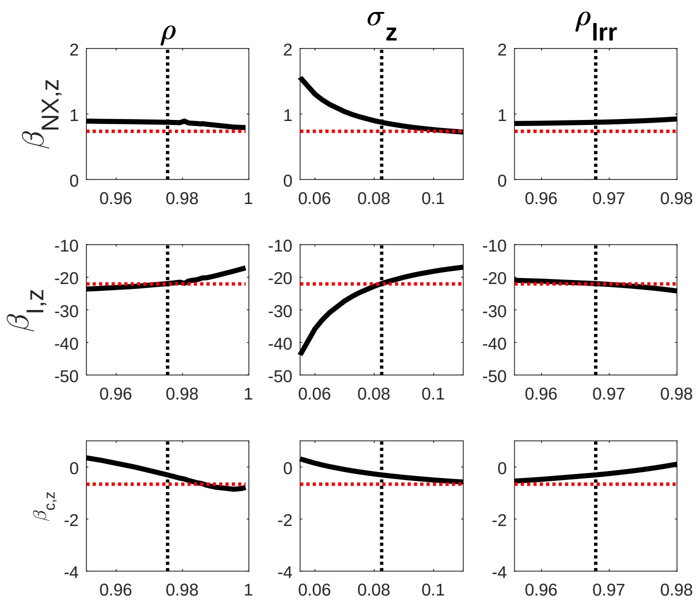

FIG. 4. Estimates of the auxiliary model. The top panels of this figure show the model-implied sensitivity of the net exports to the estimated news shocks, $\beta_{NX,z}$, as we vary the structural parameters that determine the persistence (ρ), the relative volatility (σ_z), and the cross-country correlation (ρ_{lrr}) of the long-run risk processes in our model. The dotted line shows the value of $\beta_{NX,z}$ estimated in the actual data. The panels in the middle (bottom) row are constructed in the same way and refer to the sensitivity of investment (consumption) growth differentials. We vary each of the three structural parameters in a neighborhood of the point estimates reported in table 5.

across capital vintages (Ai et al. (2013)), our approach replicates key moments of both international asset prices and quantities. We regard these results to be of great interest for research in international macro-finance.

Future research should focus on the long-term fiscal and monetary policy implications of our model. It will also be important to take into consideration both private (Maggiori (2011) and Gabaix and Maggiori (2013)) and sovereign (Aguiar and Amador (2013)) credit frictions. Studying the role of capital flows in the determination of long-term price and shock elasticities (Borovička et al. (2011)) is relevant as well, especially because this could shed new light on the behavior of long-term currency risk premia (Engel (2012)) and their implications for international liabilities (Rey and Gourinchas (2007)). Furthermore, our model should be extended to study international capital flows in economies with broader forms of heterogeneity (Bhamra and Uppal (2010), Ready et al. (2012), and Hassan (2013)) and near-rational investment (Hassan and Mertens (2014a, b)). Introducing international demand shocks in the spirit of Albuquerque et al. (2015) would be important as well. All these elements should be connected to the international wedges of Levchenko et al. (2010) in order to address the relevance of recursive preferences for aggregate fluctuations.

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ONLINE APPENDIX

NOT FOR PUBLICATION

Appendix A: Data Sources

Country specific variables. The measure of productivity is obtained from the Penn World Table V.8 (Feenstra et al. 2013), and it accounts for variation in both the share of labor income and capital depreciation across countries and over time (series denoted as $rtfpna$). The Penn World table is available at `https://pwt.sas.upenn.edu/cic_main.html`.

Data for the construction of the price-dividend ratio for RoW countries are from the "International research returns" section of Kenneth French's data library (`http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html`). The US price-to-dividend ratio is obtained from the website of Robert Shiller (`http://www.econ.yale.edu/~shiller/data/ie_data.xls`). The price-to-dividend ratios for the RoW countries are calculated using cum- and ex-dividend country value-weighted dollar index returns (using "All 4 Data Items Not Reqd" series). French's data begin in 1977; for previous years we use price-dividend ratios from Campbell (2003).

Data on consumption and investment are from the Penn World Table and are expressed in constant national prices. To construct consumption from the Penn Word Tables dataset, we multiply the consumption share (denoted as csh_c) by GDP expressed in constant national prices (series denoted as $rgdpna$). We repeat the same procedure for investment using the investment share data series (denoted as csh_i).

The real risk-free rates are computed using data from the International Financial Statistics (IFS) dataset provided by the International Monetary Fund. The IFS dataset is available at `http://elibrary-data.imf.org/DataExplorer.aspx`. For each country, the real risk-free rate is computed as the difference between the nominal interest rate on government bills and realized inflation measured by the consumer price index for all items. For the United Kingdom, the retail index is used to calculate inflation. Germany's and Italy's risk-free rate series calculated by the IMF begin in 1975 and 1976, respectively. For earlier years we use data from Campbell (2003).

Net exports data and subcomponents. This section discusses how total net exports and net exports of capital goods are measured. For the bilateral Net Exports, we use two data sources. Table 1 in the main text is based on data collected from the IMF Direction of Trade Statistics (IMF-DOTS) for all pairwise combinations of the US and the rest of the G7 countries. Imports correspond to the series denoted as "Goods, Value of Imports, Cost, Insurance, Freight (CIF), US Dollars." Exports correspond to the series denoted as "Goods, Value of Exports, Free on board (FOB), US Dollars." The results in table B2 of Appendix B.3 are instead based on the imports and exports series collected from Mitchell (2007a, b, c). These series correspond to the values reported in the books' sections called "External Trade with Main Trading Partners."

For the broader aggregate of net exports, whose results are reported in table 1 (column labeled "*NX* (US Total)"), we use annual data from the Bureau of Economic Analysis (BEA) table 4.2.5 "Exports and imports by type of products." For both exports and imports, data are aggregated in six main components: (C1) Foods, feeds, and beverages; (C2) Industrial supplies and materials; (C3) Capital goods, except automotive; (C4) Automotive vehicles, engines, and parts; (C5) Consumer goods, except automotive; and (C6) Services.

In this paper, we study a model that abstracts away from both consumer durable goods and government expenditure. For this reason, we exclude the following subcomponents from both imports and exports in our empirical investigation: " Transfers under U.S. military agency sales contracts" included under (C6) services, and "Consumer Durable goods" included under (C5).

The BEA provides a detailed list of the items that are considered industrial supplies. In the context of our model, the most relevant subcomponents of these supplies (for example, finished and unfinished metals, finished and unfinished building materials, and fabrics) are better interpreted as nonperishable investment goods. For this reason, our net exports of capital goods, NXI, comprise both industrial supplies (C2 above), and capital goods (C3 above). A somewhat more accurate allocation of these supplies across investment and consumption goods may be achieved using the BEA detailed goods trade data. Unfortunately, this would come at the cost of basing our inference on a significantly shorter sample, as data are available only from 1989. Data are available at `https://www.bea.gov/international/detailed_trade_data.htm`.

Appendix B: Additional Empirical Results

In this section, we report additional results relative to the empirical analysis discussed in section 2 of the main text.

Appendix B.1: Estimates of the Productivity Process

We document some properties of the system that we use to describe the joint evolution of productivity and p/d ratios in equations (1)-(2) of the main text. We begin by allowing all the parameters to differ across countries, thus estimating an unconstrained GMM. Specifically, we estimate the parameters

$$\{\beta_a^{US}, \beta_a^{RoW}, \varsigma^{US}, \varsigma^{RoW}, \varrho^{US}, \varrho^{RoW}, \varsigma_z^{US}, \varsigma_z^{RoW}, \varrho_a, \varrho_z\},$$

using the following orthogonality conditions:

1. $\frac{1}{T}\sum_{t=1}^{T}\left(\Delta a_t^{US} - \beta_a^{US}\cdot pd_{t-1}^{US}\right)\cdot pd_{t-1}^{US} = 0,$
2. $\frac{1}{T}\sum_{t=1}^{T}\left(\Delta a_t^{RoW} - \beta_a^{RoW}\cdot pd_{t-1}^{RoW}\right)\cdot pd_{t-1}^{RoW} = 0,$
3. $\frac{1}{T}\sum_{t=1}^{T}\left(\Delta a_t^{US} - \beta_a^{US}\cdot pd_{t-1}^{US}\right)^2 - \left(\varsigma^{US}\right)^2 = 0,$
4. $\frac{1}{T}\sum_{t=1}^{T}\left(\Delta a_t^{RoW} - \beta_a^{RoW}\cdot pd_{t-1}^{RoW}\right)^2 - \left(\varsigma^{RoW}\right)^2 = 0,$
5. $\frac{1}{T}\sum_{t=1}^{T}\left(\beta_a^{US}\cdot pd_t^{US} - \varrho^{US}\cdot\beta_a^{US}\cdot pd_{t-1}^{US}\right)\cdot\beta_a^{US}\cdot pd_{t-1}^{US} = 0$
6. $\frac{1}{T}\sum_{t=1}^{T}\left(\beta_a^{RoW}\cdot pd_t^{RoW} - \varrho^{RoW}\cdot\beta_a^{RoW}\cdot pd_{t-1}^{RoW}\right)\cdot\beta_a^{RoW}\cdot pd_{t-1}^{RoW} = 0$
7. $\frac{1}{T}\sum_{t=1}^{T}\left(\beta_a^{US}\cdot pd_t^{US} - \varrho^{US}\cdot\beta_a^{US}\cdot pd_{t-1}^{US}\right)^2 - \left(\varsigma_z^{US}\cdot\varsigma^{US}\right)^2 = 0,$
8. $\frac{1}{T}\sum_{t=1}^{T}\left(\beta_a^{RoW}\cdot pd_t^{RoW} - \varrho^{RoW}\cdot\beta_a^{RoW}\cdot pd_{t-1}^{RoW}\right)^2 - \left(\varsigma_z^{RoW}\cdot\varsigma^{RoW}\right)^2 = 0,$
9. $\frac{1}{T}\sum_{t=1}^{T}\left(\Delta a_t^{US} - \beta_a^{US}\cdot pd_{t-1}^{US}\right)\cdot\left(\Delta a_t^{RoW} - \beta_a^{RoW}\cdot pd_{t-1}^{RoW}\right) - \varrho_a\cdot\varsigma^{US}\cdot\varsigma^{RoW} = 0,$
10. $\frac{1}{T}\sum_{t=1}^{T}\left(\beta_a^{US}\cdot pd_t^{US}\right)\cdot\left(\beta_a^{RoW}\cdot pd_t^{RoW}\right) - \varrho_z\cdot\varsigma_z^{US}\cdot\varsigma_z^{RoW} = 0,$

where all the variables are de-meaned. Given that we typically cannot reject the null hypothesis that all the parameters are identical across countries, in what follows we focus on the pooled case in which $\beta_a^{US} = \beta_a^{RoW} = \beta_a$, $\varsigma_a^{US} = \varsigma_a^{RoW} = \varsigma_a$, $\varrho^{US} = \varrho^{RoW} = \varrho$, $\varsigma_z^{US} = \varsigma_z^{RoW} = \varsigma_z$.

TABLE B1: Productivity Dynamics

	β_a	ς	R^2	ϱ	ς_z	ϱ_a	ϱ_z
Panel A: GDP Weighted							
Estimate	0.009	1.145	0.060	0.938	0.101	0.442	0.789
	(0.001)	(0.074)		(0.036)	(0.011)	(0.056)	(0.062)
$H_0 : US = RoW$	[0.112]	[0.013]		[0.527]	[0.077]		
Panel B: Equally Weighted							
Estimate	0.009	1.130	0.059	0.939	0.103	0.500	0.848
	(0.001)	(0.074)		(0.035)	(0.012)	(0.055)	(0.050)
$H_0 : US = RoW$	[0.174]	[0.009]		[0.470]	[0.079]		
Panel C: Market Cap Weighted							
Estimate	0.009	1.136	0.061	0.939	0.103	0.495	0.818
	(0.001)	(0.081)		(0.036)	(0.009)	(0.055)	(0.057)
$H_0 : US = RoW$	[0.530]	[0.011]		[0.322]	[0.271]		

Notes - In this table we report estimates of the parameters that govern the transition dynamics of productivity featured in the system of equations (1) and (2) in the main text, for the case in which $z^i_{t-1} = \beta_a \cdot pd^i_{t-1}$. The numbers in parentheses correspond to standard errors. The numbers in square brackets are the p-values associated with the null hypothesis that each coefficient is identical in the US and the RoW. The RoW quantities are obtained by aggregating the remaining G7 countries using GDP shares (panel A), equal weights (panel B), and market capitalization shares (panel C). Data sources are detailed in Appendix A. Our sample starts in 1973 and ends in 2006.

In table B1 we report the pooled estimated parameters, the associated standard error, and the p-value for the null hypothesis that the estimated coefficients are identical in the US and the RoW for the system in (1) and (2) in the main text. We document several results. First, all the parameters governing the transition dynamics of productivity in the auxiliary system are tightly identified. Second, the autocorrelation of the predictive component of productivity growth is extremely high and close to 1. This means that shock to the expected component have a lasting impact on future growth. Third, we typically cannot reject the null hypothesis that the US and the RoW feature the same parameters. The only parameter for which we cannot consistently reject our null hypothesis is the short-run volatility of productivity (σ). The point estimate for this parameter is 1.35 (with a standard error of 0.19) for the US and 0.93 (with a standard error of 0.11) for the RoW. We explain the lower volatility of the RoW aggregates as originating from the imperfect correlation of the growth rates of productivity in the remaining G7 countries. Mechanically, the aggregation of the remaining six countries smooths fluctuations. Last, but not least, the correlations of the expected components of productivity are always larger than their unanticipated counterparts, and very close to unity.

Appendix B.2: Estimates of Response to Shocks

In what follows, we shall denote

$$\begin{aligned}
\varepsilon_{a,t}^{US} &= \Delta a_t^{US} - \beta_a \cdot pd_{t-1}^{US} \\
\varepsilon_{a,t}^{RoW} &= \Delta a_t^{RoW} - \beta_a \cdot pd_{t-1}^{RoW} \\
\varepsilon_{z,t}^{US} &= \beta_a \cdot pd_t^{US} - \varrho \cdot \beta_a \cdot pd_{t-1}^{US} \\
\varepsilon_{z,t}^{RoW} &= \beta_a \cdot pd_t^{RoW} - \varrho \cdot \beta_a \cdot pd_{t-1}^{RoW},
\end{aligned}$$

where the parameters $\{\beta_a, \varrho\}$ are jointly estimated with each set of moment conditions reported below.

Net Exports regression. We estimate the parameters featured in equation (3) in the manuscript along with $\beta_a^{US} = \beta_a^{RoW} = \beta_a$, and $\varrho^{US} = \varrho^{RoW} = \varrho$, using moment conditions (1), (2), (5), and (6) in Appendix B.1 together with the following moment conditions:

11. $\frac{1}{T}\sum_{t=1}^{T}\left[\Delta\left(\frac{NX_t^{US}}{GDP_t}\right) - \beta_{NX,a}\cdot\left(\varepsilon_{a,t}^{US} - \varepsilon_{a,t}^{RoW}\right) - \beta_{NX,pd}\cdot\left(\varepsilon_{z,t}^{US} - \varepsilon_{z,t}^{RoW}\right)\right]\cdot\left(\varepsilon_{a,t}^{US} - \varepsilon_{a,t}^{RoW}\right) = 0$
12. $\frac{1}{T}\sum_{t=1}^{T}\left[\Delta\left(\frac{NX_t^{US}}{GDP_t}\right) - \beta_{NX,a}\cdot\left(\varepsilon_{a,t}^{US} - \varepsilon_{a,t}^{RoW}\right) - \beta_{NX,pd}\cdot\left(\varepsilon_{z,t}^{US} - \varepsilon_{z,t}^{RoW}\right)\right]\cdot\left(\varepsilon_{z,t}^{US} - \varepsilon_{z,t}^{RoW}\right) = 0.$

Investments regressions. We estimate the parameters featured in equation (4) in the manuscript along with $\beta_a^{US} = \beta_a^{RoW} = \beta_a$, and $\varrho^{US} = \varrho^{RoW} = \varrho$, using moment conditions (1), (2), (5), and (6) in Appendix B.1 together with the following moment conditions:

13. $\frac{1}{T}\sum_{t=1}^{T}\left[\Delta I_t^{US} - \Delta I_t^{RoW} - \beta_{I,a}\cdot(\varepsilon_{a,t}^{US} - \epsilon_{a,t}^{RoW}) - \beta_{I,pd}\cdot(\varepsilon_{z,t}^{US} - \varepsilon_{z,t}^{RoW})\right]\cdot(\varepsilon_{a,t}^{US} - \epsilon_{a,t}^{RoW}) = 0$
14. $\frac{1}{T}\sum_{t=1}^{T}\left[\Delta I_t^{US} - \Delta I_t^{RoW} - \beta_{I,a}\cdot(\varepsilon_{a,t}^{US} - \epsilon_{a,t}^{RoW}) - \beta_{I,pd}\cdot(\varepsilon_{z,t}^{US} - \varepsilon_{z,t}^{RoW})\right]\cdot(\varepsilon_{z,t}^{US} - \epsilon_{z,t}^{RoW}) = 0.$

Consumption regressions. We estimate the parameters featured in equation (5) in the manuscript along with $\beta_a^{US} = \beta_a^{RoW} = \beta_a$, and $\varrho^{US} = \varrho^{RoW} = \varrho$, using moment conditions (1), (2), (5), and (6) in Appendix B.1 together with the following moment conditions:

TABLE B2: Empirical Evidence

	NX *(Bilateral, Mitchell)*	***NXI*** *(Total US NX of Investments)*
Panel A: GDP Weighted		
a	-0.122^{***}	-0.275^{***}
	(0.017)	(0.034)
z	1.223^{**}	1.383^{**}
	(0.529)	(0.689)
Panel B: Equally Weighted		
a	-0.119^{***}	-0.274^{***}
	(0.232)	(0.046)
z	1.202^{***}	1.412^{**}
	(0.452)	(0.682)
Panel C: Market Cap Weighted		
a	-0.133^{***}	-0.275^{***}
	(0.022)	(0.046)
z	1.137^{**}	1.436^{**}
	(0.480)	(0.724)

Notes - In this table we report estimates for the response of the bilateral net exports between the US and the RoW, and total US net exports of investments to relative shocks to the unanticipated (a) and expected (z) components of productivity. Bilateral net exports data are obtained from Mitchell (2007a, b, c). The RoW quantities are aggregated by weighting the remaining G7 countries by their share of GDP (panel A), equally (panel B), and market capitalization (panel C) . The superscripts ***, **, and * denote significance at the 1%, 5%, and 10% confidence levels, respectively. Data sources are detailed in Appendix A. Our sample starts in 1973 and ends in 2006.

15. $\frac{1}{T}\sum_{t=1}^{T}\left[\Delta c_t^{US} - \Delta c_t^{RoW} - \beta_{c,a}\cdot(\varepsilon_{a,t}^{US} - \epsilon_{a,t}^{RoW}) - \beta_{c,pd}\cdot(\varepsilon_{z,t}^{US} - \varepsilon_{z,t}^{RoW})\right]\cdot(\varepsilon_{a,t}^{US} - \epsilon_{a,t}^{RoW}) = 0$

16. $\frac{1}{T}\sum_{t=1}^{T}\left[\Delta c_t^{US} - \Delta c_t^{RoW} - \beta_{c,a}\cdot(\varepsilon_{a,t}^{US} - \epsilon_{a,t}^{RoW}) - \beta_{c,pd}\cdot(\varepsilon_{z,t}^{US} - \varepsilon_{z,t}^{RoW})\right]\cdot(\varepsilon_{z,t}^{US} - \epsilon_{z,t}^{RoW}) = 0.$

Appendix B.3: Additional Series of Net Exports

In table B2 we report the results of the regression specification in equation (3) in the main text obtained by replacing the series on the left-hand side with the bilateral *NX* between the US and the RoW obtained by aggregating the data from Mitchell (2007a, b, c) (first column) and with total net exports of investments (*NXI*) of the US versus the remainder of the world (second column). The table documents the same behavior of net exports that we have highlighted in the main text, namely that net exports increase in response to a positive relative long-run shock and fall in response to a positive relative short-run shock. The results are robust to all the aggregation methods for the RoW variables that we have employed throughout the rest of the paper.

Appendix B.4: Decomposition of R^2 for NX Regressions

In Table B3, we report additional results for the regressions of bilateral net exports between the US and the RoW onto the spread of shocks to the expected and unanticipated component of productivity,

$$\Delta\left(\frac{NX_t^{US}}{GDP_t}\right) \quad = \quad \beta_{NX,a}\cdot\left(\varepsilon_{a,t}^{US}-\varepsilon_{a,t}^{RoW}\right)+\beta_{NX,z}\cdot\left(\varepsilon_{z,t}^{US}-\varepsilon_{z,t}^{RoW}\right)+\xi_t,$$

as in equation (3). The total R^2s in these regressions are usually in the range of 20%. A large fraction of these R^2s, ranging from about 60% to almost 75%, is accounted by the shocks to the predictive components of productivity, as documented in the last column of table B3.

TABLE B3: Relative R^2

a	z	R^2 Total	R^2 LR share
Panel A: GDP Weighted			
-0.096^{***}	1.072^{**}	0.218	0.596
(0.020)	(0.446)	(0.103)	(0.237)
Panel B: Equally Weighted			
-0.083^{***}	1.028^{**}	0.190	0.731
(0.025)	(0.402)	(0.103)	(0.218)
Panel C: Market Cap Weighted			
-0.100^{***}	0.917^{**}	0.183	0.642
(0.028)	(0.395)	(0.102)	(0.235)

Notes - In this table we report the estimates for the regressions of bilateral net exports between the US and the RoW (columns 1 and 2) onto relative shocks to the unanticipated (a) and expected (z) components of productivity. Bilateral net exports data are obtained from IMF DOTS. Columns 3 and 4 report the total R^2 of each regression and the share of the R^2 that is represented by the two relative shocks. The RoW quantities are obtained by aggregating the remaining G7 countries using GDP shares (panel A), equal weights (panel B), and market capitalization shares (panel C). The superscripts ***, **, and * denote significance at the 1%, 5%, and 10% confidence levels, respectively. Data sources are detailed in Appendix A. Our sample starts in 1973 and ends in 2006.

Appendix C: Additional Results for the Model

In this section, we derive the approximated solution of our two-period model. We then report our derivations for the infinite horizon model, along with key results for our aggregation with heterogeneous capital vintages.

Appendix C.1: Derivations for the Two-Period Model

Shock and information structure. In this section, we present a simplified two-period version of the model in order to provide intuition on the capital reallocation motives induced by recursive preferences. Specifically, at time $t = 1$ agents receive news θ about the productivity that capital will have at time $t = 2$. Since θ does not alter productivity at time $t = 1$, it represents a pure news shock. For simplicity, no other shock materializes at $t = 1, 2$.

At time $t = 0$, that is, before the arrival of the news, agents have the same wealth and consumption level, and exchange a complete set of θ-contingent securities to maximize their time-0 utility. As a result, the time-1 reallocation can be interpreted as a deviation from the symmetric steady state.

Utility and technology. In what follows, we take advantage of lognormality wherever possible. Up to a log linearization of the allocation shares, this modeling strategy enables us to get a simple closed-form solution. In this spirit, we start by assuming that agents have an IES equal to 1, that is, their preferences can be expressed as follows:

$$u_0^i = \begin{cases} (1-\beta)\log C_0^i + \frac{\beta}{1-\gamma}\log E_0[exp\{u_1^i(1-\gamma)\}] & \gamma \neq 1 \\ (1-\beta)\log C_0^i + \beta E_0[u_1^i] & \gamma = 1 \end{cases} \tag{C1}$$

where

$$C_t = X_t^{\lambda} Y_t^{(1-\lambda)}, \quad C_t^* = X_t^{*(1-\lambda)} Y_t^{*\lambda}, \quad \text{for } t = 1, 2 \tag{C2}$$

and

$$u_1^i = (1-\beta)\log C_1^i + \beta(1-\beta)\log C_2^i.$$

Notice that in our setting uncertainty is fully resolved at time 1, and hence time-2 quantities are known at time 1. We set $C_0^h = C_0^f = \overline{C} > 0$ for symmetry and without loss of generality, as these variables play no role in the future allocation.

The resource constraints are specified as follows:

$$\begin{aligned} 1 &= X_1 + X_1^* + I_{x,1} + I_{y,t}, \qquad 1 = Y_1 + Y_1^* + I_{x,1}^* + I_{y,1}^* \qquad t = 1 \\ e^{\theta} G(I_{x,1}, I_{x,1}^*) &= X_2 + X_2^*, \qquad e^{-\theta} G^*(I_{y,1}, I_{y,1}^*) = Y_2 + Y_2^* \qquad t = 2 \\ G &= I_{x,1}^{\lambda_i} I_{x,1}^{*1-\lambda_i}, \qquad G^* = I_{y,1}^{1-\lambda_i} I_{y,1}^{*\lambda_i} \\ &\theta \sim iidN(0, \sigma) \end{aligned}, \tag{C3}$$

and are consistent with the assumption of full capital depreciation in our benchmark setting. This assumption helps with log linearity.

Total production at time $t = 1$ is predetermined, like in a production economy in which labor does not adjust upon the arrival of news. Since the relative reallocation induced by θ does not depend on the time-1 size of the economy, we normalize total production to be 1.

Finally, we assume that θ affects both domestic and foreign productivity to preserve symmetry in our equations. In what follows, we show that the results are driven only by the relative cross-country productivity, 2θ.

Pareto problem. Under complete markets, the allocation can be recovered by solving the following Pareto problem:

$$\max_{\{\{X_t, X_t^*, Y_t, Y_t^*\}_{t=1,2}, I_{x,1}, I_{y,1}, I_{x,1}^*, I_{y,1}^*\}} \mu_0 u_0 + (1 - \mu_0) u_0^*,$$

subject to the constraints specified in (C3). For the sake of symmetry, we assume $S_0 \equiv \frac{\mu_0}{1-\mu_0} = 1$.

After simplifying common coefficients, the optimality condition for the allocation of good X_1 is

$$S_1(\theta) \frac{\partial \log C_1}{\partial X_1} = \frac{\partial \log C_1^*}{\partial X_1} \tag{C4}$$

with

$$S_1(\theta) = \begin{cases} S_0, & \gamma = 1 \\ S_0 \frac{\frac{e^{u_1(1-\gamma)}}{E_0[e^{u_1(1-\gamma)}]}}{\frac{e^{u_1^*(1-\gamma)}}{E_0[e^{u_1^*(1-\gamma)}]}} = S_0 e^{(u_1(\theta)-u_1^*(\theta))(1-\gamma)} & \gamma \neq 1, \end{cases} \tag{C5}$$

where the second equality in the case of $\gamma \neq 1$ holds because of the symmetry of our problem (at the equilibrium $E_0[e^{u_1(1-\gamma)}] = E_0[e^{u_1^*(1-\gamma)}]$).

Equation (C4) establishes that the optimal allocation can be found as in a regular static problem, for a *given* value of S_1. Equation (C5) pins down S_1 and states two important results. First, in the time-additive case, the share of resources is time invariant, that is, it is not affected by the actual realization of θ. This is consistent with the special log case considered by Cole and Obstfeld (1991).

Second, with recursive preferences, agents have a preference for the variance of their future utility and hence their time-1 marginal utility depends on the time-1 level of their utility. If agents prefer early resolution of uncertainty ($\gamma > 1$), a higher relative future utility implies a lower relative marginal utility and hence a lower share of allocated resources ($u_1(\theta) > u_1^*(\theta) \rightarrow S_1(\theta) < S_0$). The opposite is true when $\gamma < 1$. Because of the dependence of S_1 on future utility levels, $u_1(\theta) - u_1^*(\theta)$, θ prompts a reallocation at time 1.

Similarly to the results derived for time 1, the optimality condition for the allocation of good X_2 is

$$S_2(\theta) \frac{\partial \log C_2}{\partial X_2} = \frac{\partial \log C_2^*}{\partial X_2} \tag{C6}$$

where

$$S_2(\theta) = S_1(\theta)$$

because uncertainty is fully resolved at time 1 and hence agents face no further news going forward, that is, $\frac{\exp\{u_2(\theta)(1-\gamma)\}}{E_1[\exp\{u_2(\theta)(1-\gamma)\}]} = \frac{\exp\{u_2^*(\theta)(1-\gamma)\}}{E_1[\exp\{u_2^*(\theta)(1-\gamma)\}]} = 1 \quad \forall \theta$. As a result, no additional variation of the pseudo-Pareto weights takes place at time 2.

CRRA case. In this case, the allocation at time 1 can be computed exactly as $S_1 = S_0 = 1$. As a result, from the home-country perspective we have the following:

$$I_{x,1} = \lambda_i \frac{\beta}{1+\beta}, \quad I_{y,1} = (1-\lambda_i)\frac{\beta}{1+\beta},$$

$$X_1 = \lambda \frac{1}{1+\beta}, \quad X_1^* = (1-\lambda)\frac{1}{1+\beta},$$

that is, a fraction $1/(1+\beta)$ of time-1 output is devoted to consumption, whereas $\beta/(1+\beta)$ is devoted to investment. The fraction of good X used for domestic consumption equals the consumption home-bias parameter λ. The fraction of good X used for investment in the home country equals the investment home-bias parameter λ_i. By symmetry, similar results apply to the foreign country. It is then possible to establish that

$$NX_1^C \equiv X_1^* - p_1 Y_1 = 0 \quad \forall \theta$$

and

$$NX_1^I \equiv I_{y,1} - p_1 I_{x,1}^* = 0 \quad \forall \theta,$$

that is, news promotes no current account adjustment.

EZ case. In this case, the allocations at $t = 1, 2$ are a nonlinear function of $S_1(\theta)$. We log linearize them with respect to $s_1 \equiv \log S_1$ around $\bar{s}_1 = s_0 = 0$ and verify that at the equilibrium the following holds:

$$u_1 = const + \lambda_u^s s_1 + \lambda_u^\theta \theta, \qquad u_1^* = const - \lambda_u^s s_1 - \lambda_u^\theta \theta, \tag{C7}$$

$$s_1 = \lambda_s^\theta \theta, \tag{C8}$$

where λ_i^j denotes the elasticity of the variable i with respect to variable j. The derivations reported in what follows prove that

$$\lambda_s^\theta = 2\frac{(2\lambda-1)(1-\gamma)}{1-2\lambda_u^s(1-\gamma)}, \tag{C9}$$

where $\lambda_u^s \geq 0$ if $\lambda \geq 1/2$, as detailed in equation (C17).

Time 2. In the final period, the allocation of $\{X_2, X_2^*, Y_2, Y_2^*\}$ satisfies what follows:

$$\begin{aligned} S_2(\theta)\frac{\partial \log C_2}{\partial X_2} &= \frac{\partial \log C_2^*}{\partial X_2} \\ S_2(\theta)\frac{\partial \log C_2}{\partial Y_2} &= \frac{\partial \log C_2^*}{\partial Y_2^*} \\ e^{\theta}G(\theta) &= X_2 + X_2^* \\ e^{-\theta}G^*(\theta) &= Y_2 + Y_2^*. \end{aligned}$$

We report the solution only for the home country allocation using the condition $S_2(\theta) = S_1(\theta)$:

$$\begin{aligned} X_2(\theta) &= SH^X(\theta)e^{\theta}G(\theta) = \frac{\kappa S_1(\theta)}{1+\kappa S_1(\theta)}e^{\theta}G(\theta) \\ Y_2(\theta) &= SH^Y(\theta)e^{-\theta}G^*(\theta) = \frac{1/\kappa S_1(\theta)}{1+1/\kappa S_1(\theta)}e^{-\theta}G^*(\theta), \end{aligned}$$

where $\kappa = \lambda/(1-\lambda)$, and SH^z is the share of good $z = X, Y$ allocated to the home (H) country. Using the resource constraints, $X_2^* = (1 - SH^X)e^{\theta}G(\theta)$, and $Y_2^* = (1 - SH^Y)e^{-\theta}G(\theta)$. After log linearizing the share processes with respect to $s_1(\theta)$ around $\overline{s} = 0$,

$$\begin{aligned} \log SH^X(\theta) &\approx \log(\lambda) + (1-\lambda)s_1(\theta) \\ \log SH^Y(\theta) &\approx \log(1-\lambda) + \lambda s_1(\theta), \end{aligned}$$

we get

$$\begin{aligned} \log C_2(\theta) &\approx \overbrace{\lambda\log(\lambda) + (1-\lambda)\log(1-\lambda)}^{constant} + \overbrace{(2\lambda-1)}^{\lambda_{C_2}^{\theta}}\theta + \overbrace{2\lambda(1-\lambda)}^{\lambda_{C_2}^{s}}s_1(\theta) \qquad \textbf{(C10)} \\ &+ \lambda\log G(\theta) + (1-\lambda)\log G^*(\theta) \\ \log C_2^*(\theta) &\approx constant - \lambda_{C_2}^{\theta}\theta - \lambda_{C_2}^{s}s_1(\theta) + (1-\lambda)\log G(\theta) + \lambda\log G^*(\theta). \end{aligned}$$

Time 1. At time 1, the planner needs to allocate both consumption goods $\{X_1, X_1^*, Y_1, Y_1^*\}$ and capital $\{I_x, I_x^*, I_y, I_y^*\}$ to solve the following problem:

$$\max(1-\delta)[S_1 \cdot (\log C_1 + \delta\log C_2) + (\log C_1^* + \delta\log C_2^*)],$$

subject to

$$
\begin{aligned}
1 &= X_1 + X_1^* + I_{x,1} + I_{y,t} \\
1 &= Y_1 + Y_1^* + I_{x,1}^* + I_{y,1}^*.
\end{aligned}
$$

The rescaling factor $(1-\delta)$ is reported just for consistency with the specification of our preferences, and it does not play any relevant role. This optimization is implemented taking θ and hence $s_1(\theta)$ as given. After solving this allocation problem, we can characterize $u_1 - u_1^*$ in equation (16) and solve a fixed point for the joint dynamics of $u_1 - u_1^*$ and $s_1(\theta)$, i.e., our main computational goal.

The FOCs with respect to X_1, X_1^*, I_x, and I_y are

$$
\begin{aligned}
X_1^* &= 1/(\kappa S_1) X_1 && \text{(C11)} \\
X_1 &= \frac{1}{\lambda_i \beta [1 + 1/(\kappa S_1])} I_x && \text{(C12)} \\
I_y &= \frac{1-\lambda_i}{\lambda_i} \frac{\lambda + (1-\lambda) S_1}{1 - \lambda + \lambda S_1} I_x && \text{(C13)}
\end{aligned}
$$

Equations (C11)–(C13) together with the resource constraint imply the following:

$$
I_x = \lambda_i \delta \frac{1}{1 + \delta\lambda_i + \delta(1-\lambda_i)\frac{\lambda+(1-\lambda)S_1}{1-\lambda+\lambda S_1}}. \tag{C14}
$$

A log-linearization of equations (C11)–(C14) with respect to $s_1(\theta)$ around $\overline{s} = 0$ produces

$$
\begin{aligned}
\log I_x &\approx \log\left(\frac{\lambda_i \delta}{1+\delta}\right) + \underbrace{\frac{\delta}{1+\delta}(1-\lambda_i)(2\lambda - 1)}_{\lambda_i^s} s_1 && \text{(C15)} \\
\log I_y &\approx \log\left(\frac{(1-\lambda_i)\delta}{1+\delta}\right) + \underbrace{\frac{1}{1+\delta}(1+\lambda_i\delta)(1-2\lambda)}_{\lambda_{i_y}^s} s_1 \\
\log X_1 &\approx \log\left(\frac{\lambda}{1+\delta}\right) + \underbrace{\left[\frac{\delta}{1+\delta}(1-\lambda_i)(2\lambda-1) + 1 - \lambda\right]}_{\lambda_x^s} s_1 \\
\log X_1^* &\approx \log\left(\frac{1-\lambda}{1+\delta}\right) + \underbrace{\left[\frac{\delta}{1+\delta}(1-\lambda_i)(2\lambda-1) - \lambda\right]}_{\lambda_{x^*}^s} s_1.
\end{aligned}
$$

By symmetry:

$$
\begin{aligned}
\log I_x^* &\approx \log\left(\frac{(1-\lambda_i)\delta}{1+\delta}\right) - \lambda_{i_y}^s s_1, \qquad \log I_y^* \approx \log\left(\frac{\lambda_i \delta}{1+\delta}\right) - \lambda_i^s s_1, \\
\log Y_1^* &\approx \log\left(\frac{\lambda}{1+\delta}\right) - \lambda_x^s s_1, \qquad \log Y_1 \approx \log\left(\frac{1-\lambda}{1+\delta}\right) - \lambda_{x^*}^s s_1.
\end{aligned}
$$

We are now ready to characterize the utility functions at time 1:

$$
\begin{aligned}
u_1 &= (1-\delta)(\log C_1 + \delta \log C_2) \approx const + \lambda_u^\theta \theta + \lambda_u^s s_1 = const + \overbrace{(\lambda_u^\theta + \lambda_u^s \cdot \lambda_s^\theta)}^{\lambda_u}\theta \\
u_1^* &= (1-\delta)(\log C_1^* + \delta \log C_2^*) \approx const - \lambda_u^\theta \theta - \lambda_u^s s_1 = const - \lambda_u \theta,
\end{aligned}
$$

where

$$
\begin{aligned}
\lambda_u^\theta &= \lambda_{C_2}^\theta (1-\delta)\delta = (2\lambda - 1)(1-\delta)\delta && \text{(C16)} \\
\lambda_u^s &= (1-\delta)[\lambda \cdot \lambda_x^s + (1-\lambda)(-\lambda_{x^*}^s)] && \text{(C17)} \\
&+ \delta(1-\delta)(2\lambda-1)(\lambda_i \cdot \lambda_i^s + (1-\lambda_i)(-\lambda_{i_y}^s)) \\
\lambda_s^\theta &: s_1(\theta) = \lambda_s^\theta \theta. && \text{(C18)}
\end{aligned}
$$

Given the equilibrium condition (16),

$$
\lambda_s^\theta = -2(\gamma - 1)\lambda_u \to \lambda_s^\theta - 2\lambda_u^s(\gamma-1)\lambda_u = \lambda_u,
$$

and hence

$$
\lambda_s^\theta = \frac{2(1-\gamma)(1-\delta)\delta(2\lambda-1)}{1+2\lambda_u^s(\gamma-1)}. \tag{C19}
$$

Lemma 1. *If $\lambda > 1/2$, $\lambda_i \in (0,1)$, and $\gamma > 1$, then $\lambda_s^\theta < 0$.*

Proof. If $\lambda > 1/2$ and $\gamma > 1$, the numerator of equation (C19) is negative. Since $\lambda_i \in (0,1)$, in the system of equations (C15) home bias implies that (i) $\lambda_i^s > 0$ and $-\lambda_{i_y}^s > 0$, and (ii) $\lambda_x^s > 0$ and $-\lambda_{x^*}^s > 0$. As a result, according to equation (C17) we have $\lambda_u^s > 0$. Given these conditions, the denominator of (C19) is positive. □

Time-1 net exports. According to the definition of net exports of consumption goods, from the home-country perspective we have

$$\frac{NX_1^C}{X_1} = \frac{X_1^*}{X_1} - \underbrace{\left(\frac{1-\lambda}{\lambda}\frac{X_1}{Y_1}\right)}_{p_1}\frac{Y_1}{X_1} = -\frac{1-\lambda}{\lambda}\left(1-\frac{1}{S_1}\right),$$

where p_1 is the terms of trade. Similarly, for the net exports of investment we obtain

$$\frac{NX_1^I}{I_x} = \frac{I_y}{I_x} - \underbrace{\left(\frac{1-\lambda_i}{\lambda_i}\frac{I_x}{I_x^*}\right)}_{p_1}\frac{I_x^*}{I_x} = -\frac{1-\lambda_i}{\lambda_i}\left(1-\frac{S_1+\kappa}{\kappa S_1+1}\right).$$

Appendix C.2: Pareto Problem, Infinite Horizon

For the sake of brevity, in this appendix we suppress notation to denoting state and histories and retain only subscripts for time. We represent the Epstein and Zin (1989) utility preference in the following compact way:

$$U_t = W(\widetilde{C}_t, U_{t+1}),$$

so that the dependence of current utility on j-step-ahead consumption can easily be denoted as follows:

$$\frac{\partial U_t}{\partial \widetilde{C}_{t+j}} = W_{2,t+1}\cdot W_{2,t+2}\cdot\cdots\cdot W_{2,t+j}W_{1,t+j}, \tag{C20}$$

where $W_{2,t+j} \equiv \frac{\partial U_{t+j-1}}{\partial U_{t+j}}$ and $W_{1,t+j} \equiv \frac{\partial U_{t+j}}{\partial \widetilde{C}_{t+j}}$. Given this notation, the intertemporal marginal rate of substitution between $\widetilde{C}_t$ and $\widetilde{C}_{t+1}$ is

$$IMRS_{\widetilde{C},t+1} = \frac{W_{2,t+1}W_{1,t+1}}{W_{1,t}} = M_{t+1}\pi_{t+1}, \tag{C21}$$

where π_{t+1} is the probability of a specific state, and M_{t+1} is the stochastic discount factor in $\widetilde{C}$ units with the following form:

$$M_{t+1} = \beta\left(\frac{\widetilde{C}_{t+1}}{\widetilde{C}_t}\right)^{-\frac{1}{\psi}}\left(\frac{U_{t+1}}{E_t\left[U_{t+1}^{1-\gamma}\right]^{\frac{1}{1-\gamma}}}\right)^{\frac{1}{\psi}-\gamma}. \tag{C22}$$

The consumption bundle, $\widetilde{C}$, depends on both the consumption aggregate, C, and labor, N:

$$\widetilde{C}_t = \widetilde{C}(C_t, N_t).$$

The consumption aggregate combines two goods, x and y:

$$C_t = C(X_t, Y_t).$$

The planner faces the following constraints:

$$F(A_t, K_t, N_t) \geq X_t + X_t^* + I_{x,t} + I_{y,t} \tag{C23}$$

$$F(A_t^*, K_t^*, N_t^*) \geq Y_t + Y_t^* + I_{x,t}^* + I_{y,t}^* \tag{C24}$$

$$K_t \leq (1-\delta)K_{t-1} + e^{\omega_t} G(I_{x,t-1}, I_{x,t-1}^*) \tag{C25}$$

$$K_t^* \leq (1-\delta)K_{t-1}^* + e^{\omega_t^*} G^*(I_{y,t-1}, I_{y,t-1}^*), \tag{C26}$$

where A_t and A_t^* are the exogenous stochastic productivity processes in equation (19). The processes $w_t = -\frac{1-\alpha}{\alpha}(\Delta a_t - \mu)$ and $w_t^* = -\frac{1-\alpha}{\alpha}(\Delta a_t^* - \mu)$ result from the vintage capital structure assumed in Ai et al. (2013).

The social planner chooses $\left\{X_t, X_t^*, Y_t, Y_t^*, N_t, N_t^*, K_t, K_t^*, I_{x,t}, I_{y,t}, I_{x,t}^*, I_{y,t}^*\right\}_t$ to maximize

$$\mu_0 W_0 + (1-\mu_0) W_0^*,$$

subject to sequences of constraints (C23)–(C26). Specifically, let $\lambda_{i,t}$ be the Lagrangian multiplier for the time t constraint (Bi); then the Lagrangian is

$$
\begin{aligned}
\Omega =& \mu_0 W_0 + (1-\mu_0)W_0^* \\
& + ... \\
& + \lambda_{1,t}(F(A_t, K_t, N_t) - X_t - X_t^* - I_{x,t} - I_{y,t}) \\
& + \lambda_{2,t}(F(A_t^*, K_t^*, N_t^*) - Y_t - Y_t^* - I_{x,t}^* - I_{y,t}^*) \\
& + \lambda_{3,t}((1-\delta)K_{t-1} + e^{\omega_t}G(I_{x,t-1}, I_{x,t-1}^*) - K_t) \\
& + \lambda_{4,t}((1-\delta)K_{t-1}^* + e^{\omega_t^*}G^*(I_{y,t-1}, I_{y,t-1}^*) - K_t^*) \\
& + ...
\end{aligned}
$$

The optimality condition for the allocation of good X_t for $t = 1, 2, ...$ in each possible state is

$$
\mu_0 \cdot \left(\prod_{j=1}^{t} W_{2,j}\right) \cdot W_{1,t}\widetilde{C}_{C,t}C_{x,t} = \lambda_{1,t} = C_{x^*,t}^*\widetilde{C}_{C^*,t}^*W_{1,t}^* \cdot \left(\prod_{j=1}^{t} W_{2,j}^*\right) \cdot \mu_0^*, \tag{C27}
$$

where $\mu_0^* = (1-\mu_0)$, $\widetilde{C}_{C,t} = \partial\widetilde{C_t}/\partial C_t$, $C_{x,t} = \partial C_t/\partial x_t$, and the analogous partial derivatives for the foreign country are denoted by an asterisk.

Define μ_t as the date t Pareto weight for the home country. Using equation (C21), we obtain

$$
\begin{aligned}
\mu_t &= \mu_0 \cdot \left(\prod_{j=1}^{t} W_{2,j}\right) \cdot W_{1,t}C_t \\
&= \mu_{t-1} \cdot W_{2,t}^i \cdot \frac{W_{1,t}}{W_{1,t-1}} \cdot \frac{C_t}{C_{t-1}} = \mu_{t-1} \cdot M_t \cdot \frac{C_t}{C_{t-1}}.
\end{aligned}
$$

It follows that equation (C27) can be rewritten as

$$
\mu_t \cdot \widetilde{C}_{C,t}C_{x,t}\frac{1}{C_t} = \frac{1}{C_t^*}C_{x^*,t}^*\widetilde{C}_{C^*,t}^* \cdot \mu_t^*. \tag{C28}
$$

Let $S_t \equiv \mu_t/\mu_t^*$, and note that with GHH preferences, $\widetilde{C}_{C,t} = 1$; that is, equation (C22) holds also for the discount factor in C units. Then the optimality condition in equation (C28) can be represented by the following system of recursive equations:

$$
\begin{aligned}
S_t \cdot C_{x,t} \cdot \frac{1}{C_t} &= C^*_{x^*,t} \cdot \frac{1}{C^*_t} \\
S_t &= S_{t-1} \frac{M_t e^{\Delta c_t}}{M^*_t e^{\Delta c^*_t}}.
\end{aligned} \tag{C29}
$$

In a similar fashion, the optimal allocation of good Y is determined by

$$
S_t \cdot C_{y,t} \cdot \frac{1}{C_t} = C^*_{y^*,t} \cdot \frac{1}{C^*_t}.
$$

Given our GHH preferences, the optimal allocation of labor implies the following standard intratemporal conditions:

$$
\begin{aligned}
\widetilde{C}_{N,t} &= -F_{N,t} C_{X,t} \\
\widetilde{C}^*_{N^*,t} &= -F^*_{N^*,t} C^*_{Y^*,t},
\end{aligned}
$$

where $C_{X,t} = \partial C_t / \partial X_t$, $C^*_{Y^*,t} = \partial C^*_t / \partial Y^*_t$, $\widetilde{C}_{N,t} = \partial \widetilde{C}_t / \partial N_t$, and $F_{N,t} = \partial F_t / \partial N_t$.

Let s_{t+1} index the possible states at time $t+1$. The first-order condition with respect to $I_{x,t}$ is

$$
\begin{aligned}
-\lambda_{1t} + \sum_{s_{t+1}} (\lambda_{3,t+1} e^{\omega_{t+1}} G_{I_x,t}) &= 0 \\
\Leftrightarrow \sum_{s_{t+1}} \left(\frac{\lambda_{1,t+1}}{\lambda_{1,t}} \frac{\lambda_{3,t+1}}{\lambda_{1,t+1}} \omega^h_{t+1} \right) &= \frac{1}{G_{I_x,t}}.
\end{aligned}
$$

By definition, $IMRS^x_{t+1|t} = \frac{\lambda_{1,t+1}}{\lambda_{1,t}} = \frac{\partial U_0 / \partial x_{t+1}}{\partial U_0 / \partial x_t} = M^x_{t+1} \pi_{t+1|t}$ for $i \in \{h, f\}$, where M^x_{t+1} is the stochastic discount factor in X-units. Substituting the stochastic discount factor into the above equation, we have

$$
\frac{1}{G_{I_x,t}} = E_t[M^x_{t+1} P_{k,t+1} e^{\omega_{t+1}}], \tag{C30}
$$

where $G_{I_x,t} \equiv \frac{\partial G(I_{x,t}, I^*_{x,t})}{\partial I_{x,t}}$, and $P_{k,t+1} \equiv \frac{\lambda_{3,t+1}}{\lambda_{1,t+1}}$ is the cum-dividend price of capital in X-units.

The optimal accumulation of K_t has to satisfy

$$-\lambda_{3,t} + \lambda_{1,t} F_{k,t} + \sum_{s_{t+1}} ((1-\delta)\lambda_{3,t+1}) = 0$$
$$\Leftrightarrow E_t[M^x_{t+1}(1-\delta)P_{k,t+1}] + F_{k,t} = P_{k,t},$$

where $F_{k,t} \equiv \frac{\partial F}{\partial k_t}$. Define $Q_{k,t} \equiv E_t[M^x_{t+1} P_{k,t+1}]$ as the ex-dividend price of capital. Then we have

$$P_{k,t} = F_{k,t} + (1-\delta) Q_{k,t}$$
$$Q_{k,t} = E_t[M^x_{t+1} P_{k,t+1}]$$

and

$$R_{k,t+1} = \frac{P_{k,t+1}}{Q_{k,t}}.$$

The first-order condition with respect to $I_{y,t}$ states the following:

$$-\lambda_{1,t} + \sum_{s_{t+1}} \left(\lambda_{4,t+1} e^{\omega^*_{t+1}} G^*_{I_y,t} \right) = 0$$
$$\Leftrightarrow \sum_{s_{t+1}} \left(\frac{\lambda_{1,t+1}}{\lambda_{1,t}} \frac{\lambda_{4,t+1}}{\lambda_{2,t+1}} \frac{\lambda_{2,t+1}}{\lambda_{1,t+1}} e^{\omega^*_{t+1}} \right) = \frac{1}{G^*_{I_y,t}},$$

where $G^*_{I_y,t} \equiv \frac{\partial G^*_t}{\partial I_{y,t}}$. Similarly to what done for the home country, define $P^*_{k,t+1} \equiv \frac{\lambda_{4,t+1}}{\lambda_{2,t+1}}$ as the cum-dividend price of capital in Y-units and note that $P_{t+1} = \frac{\lambda_{2,t+1}}{\lambda_{1,t+1}}$ measures the terms of trade. It is then possible to obtain that

$$\frac{1}{G^*_{I_y,t}} = E_t[M^x_{t+1} P^*_{k,t+1} P_{t+1} e^{\omega^*_{t+1}}]. \tag{C31}$$

Define $M^y_{t+1} \equiv \frac{\lambda_{2,t+1}}{\lambda_{2,t}}$ as the SDF in Y-units. The remaining first-order conditions imply

$$\begin{aligned}
\frac{1}{G^*_{I^*_y,t}} =& E_t[M^y_{t+1} P^*_{k,t+1} e^{\omega^*_{t+1}}] \qquad \text{(C32)} \\
P^*_{k,t} =& F^*_{k,t} + (1-\delta) Q^*_{k,t} \\
R^*_{k,t+1} =& \frac{P^*_{k,t+1}}{Q^*_{k,t}} \\
Q^*_{k,t} =& E_t[M^y_{t+1} P^*_{k,t+1}] \\
\frac{1}{G_{I^*_x,t}} =& E_t\left[M^y_{t+1} P_{k,t+1} \frac{1}{P_t} e^{\omega_{t+1}}\right].
\end{aligned}$$

We use perturbation methods to solve our system of equations. We compute our policy functions using the dynare++4.2.1 package. All variables included in our dynare++ code are expressed in log units.

Appendix C.3: Aggregation with Vintage Capital

In what follows, we confirm the aggregation results proved in Ai et al. (2013).

Lemma 2. *Suppose there are m types of firms. For $i = 1, 2, 3, \cdots m$, the productivity of the type i firm is denoted by $A(i)$, and the total measure of the type i firm is denoted by $F(i)$. The production technology of the type i firm is given by*

$$y(i) = [A(i)\, n(i)]^{1-\alpha},$$

where $n(i)$ denotes the labor hired at firm i. The total labor supply in the economy is N. Then total output is given by

$$Y = \left[\sum_{i=1}^{m} F(i) \left[\frac{A(i)}{A(1)}\right]^{\frac{1-\alpha}{\alpha}}\right]^{\alpha} [A(1)\, N]^{1-\alpha}.$$

Proof. Without loss of generality, we assume that firms of the same type employ the same amount of labor. In this case, the total output in the economy is given by

$$Y = \max \sum_{i=1}^{m} F(i)\, A(i)^{1-\alpha}\, n(i)^{1-\alpha} \tag{C33}$$
$$\textit{subject to} \sum_{i=1}^{m} F(i)\, n(i) = N.$$

The first-order condition of the above optimization problem implies that for all i,

$$\frac{n(i)}{n(1)} = \left(\frac{A(i)}{A(1)}\right)^{\frac{1-\alpha}{\alpha}}.$$

Using the resource constraint,

$$\sum_{i=1}^{m} F(i) \left(\frac{A(i)}{A(1)}\right)^{\frac{1-\alpha}{\alpha}} n(1) = N,$$

we determine the labor employed in firm 1:

$$n(1) = \left[\sum_{i=1}^{m} F(i) \left[\frac{A(i)}{A(1)}\right]^{\frac{1-\alpha}{\alpha}}\right]^{-1} N. \tag{C34}$$

Using equations (C33)–(C34), we have:

$$\begin{aligned} Y &= \sum_{i=1}^{m} F(i)\, A(i)^{1-\alpha} \left[\left(\frac{A(i)}{A(1)}\right)^{\frac{1-\alpha}{\alpha}} n(1)\right]^{1-\alpha} \\ &= [A(1)\, n(1)]^{1-\alpha} \left[\sum_{i=1}^{m} F(i) \left(\frac{A(i)}{A(1)}\right)^{\frac{1-\alpha}{\alpha}}\right] \\ &= [A(1)\, N]^{1-\alpha} \left[\sum_{i=1}^{m} F(i)\, A(i)^{\frac{1-\alpha}{\alpha}}\right]^{\alpha}, \end{aligned}$$

as needed. □

At time t, there are $t+1$ types of operating production units in the economy, namely, production units of generation $-1, 0, 1, \cdots, t-1$. The measures of these production units are $(1-\delta_K)^t K_0$, $(1-\delta_K)^{t-1} G_0$, $(1-\delta)^{t-2} G_1, \cdots, G_{t-1}$. Using the above lemma, at date t, the total production in the economy is given by

$$Y_t = A_t \left[(1-\delta_K)^t K_0 + \sum_{\tau=0}^{t-1} (1-\delta_K)^{t-\tau-1} G_\tau \left(\frac{A_t^\tau}{A_t}\right)^{\frac{\alpha-1}{\alpha}}\right]^{\alpha} N_t^{1-\alpha}.$$

Table C1: Model Sensitivity Analysis

Panel A: the role of the IES (ψ)					
Moments	Data		EZ-BKK	IES=1	IES=1.5
E[r_f] (%)	1.32 (0.64)		2.31	2.96	1.03
corr($\Delta c, \Delta c^*$)	0.37 (0.11)		0.25	0.24	0.47
β_{LR}^{NX}	1.07 (0.45)		1.24	1.29	1.21
Panel B: the role of the RRA (γ)					
Moments	Data		EZ-BKK	RRA=5	RRA=15
StD(Δi)/Std(Δx^T)	2.36 (0.26)		2.24	2.24	2.41
E[r_f] (%)	1.32 (0.64)		2.31	3.60	1.24
StD(Δe)	5.93 (0.77)		4.65	3.88	5.14
corr($\Delta c, \Delta c^*$)	0.37 (0.11)		0.25	0.16	0.32
β_{LR}^{NX}	1.07 (0.45)		1.24	1.10	1.33
Panel C: the role of home bias ($\lambda = \lambda_I$)					
Moments	Data	EZ-BKK	$\lambda = .85$	$\lambda = .95$	$\lambda = .95$ (RRA=3)
corr($\Delta \frac{NX}{X^T}, \Delta x^T$)	-0.36 (0.13)	-0.16	-0.53	0.27	-0.32
corr($\Delta i, \Delta i^*$)	0.33 (0.17)	0.39	0.07	0.61	0.34
corr($\Delta c, \Delta c^*$)	0.37 (0.11)	0.25	0.19	0.27	0.11
Quant. Anomaly	0.15 (0.09)	-0.14	-0.06	-0.17	-0.05
StD(Δe)	5.93 (0.77)	4.65	2.52	7.41	4.44
β_{SR}^{NX}	-0.10 (0.02)	-0.01	-0.08	0.02	-0.01
β_{LR}^{NX}	1.07 (0.45)	1.24	1.45	1.14	0.76

Notes: Empirical moments are computed using annual data from 1973 to 2006. All data sources are discussed in section 2. Numbers in parentheses are Newey-West adjusted standard errors. All the parameters are calibrated as in table 2, unless otherwise specified. The entries for the models are obtained by repetitions of small-sample simulations.

Clearly, if we define the $\{K_t\}_{t=0}^{\infty}$ process recursively according to equation (23), the aggregate production function is Cobb-Douglas, as in section 4.

Appendix C.4: Sensitivity Analysis

In this section we assess the sensitivity of our results with respect to the key elements of our study, i.e., (i) the preference parameters related to the recursive risk-sharing motive, and (ii) the degree of home bias. Starting from the EZ-BKK model calibrated as in table 2, we vary one parameter of interest at a time and report the moments that change significantly in table C1. Our results refer to the case in which $\phi_0 = 1$. We have conducted the same sensitivity analysis for our EZ-BKK model with vintage capital and found virtually identical results.

The role of the IES. As we increase the IES from 1 to 1.5, the average risk-free rate declines, as is common in any economy with EZ preferences. Most importantly, the contemporaneous correlation of the growth rates of consumption increases toward the upperbound of our confidence interval, whereas the sensitivity coefficients of NX to long-run shocks declines. These results implicitly impose a relevant upper bound on what the IES should be in order to match international trade data.

The role of the RRA. Similarly to the IES case, an increase in the risk aversion coefficient decreases the average risk-free rate (precautionary motive) and increases the international correlation of consumption growth. Since the reallocation effect depends on $\gamma - 1/\psi$, higher risk aversion tends to increase the exposure of the net exports to long-run shocks. Additionally, it enhances the incentives to trade investment goods, and hence it amplifies the volatility of both national investment growth and the exchange rate.

The role of home bias. As discussed in section 3.1, consumption home bias is an important driver of the reallocation motives with respect to news shocks. In the original BKK calibration, the home bias is set to 0.85 to match total US trade. Focusing on the extent of trade of the US with the remaining G7 countries, a higher value of 0.95 is more appropriate. We consider both of these values in the last panel of table C1.

Reducing the extent of home bias makes domestic and foreign resources more substitutable. As a result, the productivity channel is more pronounced with respect to short-run shocks and the net exports become more countercyclical. Unfortunately, this channel makes the international trade of investment goods excessive and investment becomes less correlated across countries.

If we increase the consumption home bias, the risk-sharing channel becomes stronger and it dominates even with respect to short-run shocks. The net exports become positively correlated with output and their exposure to short-run shocks becomes positive as well, in contrast to the data. We note that this problem can be easily solved by simultaneously lowering the risk aversion parameter to a value as low as three. After considering this refinement, a more pronounced value of the consumption home bias enhances most of our quantitative results, including the quantity anomaly.

TABLE C2: Additional Sensitivity Analysis

Panel A: Domestic Moments	Vol. Relative to GDP			Asset Prices		Correlation($\Delta\cdot,\Delta\cdot$)				ACF(1)
	Δn	Δc	Δi	E[r_f](%)	E[r^{ex}](%)	(c,i)	(c,n)	$(\frac{NX}{X^T},x^T)$	$(\frac{NXI}{X^T},x^T)$	$\frac{NX}{X^T}$
Data:	0.74	0.65	2.36	1.32	4.58	0.69	0.82	-0.36	-0.52	0.88
	(0.08)	(0.06)	(0.26)	(0.64)	(2.15)	(0.07)	(0.03)	(0.13)	(0.13)	(0.08)
EZ-BKK	0.49	0.66	2.24	2.31	0.11	0.93	0.89	-0.16	-0.56	0.85
EZ-BKK (II)	0.49	0.61	2.53	1.99	3.26	0.83	0.84	-0.24	-0.58	0.83
EZ-BKK (III)	0.49	0.63	2.57	1.98	3.30	0.83	0.85	-0.35	-0.52	0.78

Panel B: International Moments	$\rho_h = $ corr($\Delta h, \Delta h^*$)				StD($\cdot$)(%)		Sensitivity to News			
	ρ_c	$\rho_{x^T}-\rho_c$	ρ_i	ρ_n	Δe	NX/X	β^{NX}_{SR}	β^{NX}_{LR}	R^2_{SR}/R^2	R^2_{LR}/R^2
Data:	0.37	0.15	0.33	0.53	5.93	0.56				
	(0.11)	(0.09)	(0.17)	(0.11)	(0.77)	(0.07)				
EZ-BKK	0.25	-0.14	0.39	0.25	4.65	0.52	-0.01	1.24	0.06	0.94
EZ-BKK (II)	0.29	-0.20	0.27	0.21	3.99	0.50	-0.01	1.27	0.12	0.88
EZ-BKK (III)	0.19	-0.12	0.30	0.16	5.51	0.68	-0.03	1.80	0.28	0.72

Notes: Empirical moments are computed using annual data from 1973 to 2006. All data sources are discussed in section 2 and Appendix A. Numbers in parentheses are Newey-West adjusted standard errors. Excess returns are levered as in Garca-Feijo and Jorgensen (2010). For the EZ-BKK model, all the parameters are calibrated as in table 2 and capital vintages are homogeneous ($\phi_0 = 1$). In BKK-EZ(II), we introduce vintage capital ($\phi_0 = 0$). BKK-EZ(III) features both vintage capital and heterogeneous home bias, meaning that it is solved imposing $\lambda = 0.95$ and $\lambda_I = 0.85$, so that the total imports share remains 92%. The entries for the models are obtained by repetitions of small-sample simulations. Lowercase letters denote log units.

Heterogeneous home bias. Recent studies have documented that home bias is more pronounced for investment goods than consumption goods (see, among others, Boileau (1999), Erceg et al. (2008) and Engel and Wang (2011)). In order to capture this feature, we also consider the case $\lambda_I < \lambda$. As discussed in Appendix C.3, our main results are robust to, and often enhanced by, this further extension.

Additional sensitivity analysis. In table C2, we report a comprehensive list of moments produced by our EZ-BKK model; our model augmented with vintage capital friction (EZ-BKK (II)); and our model augmented with both vintage capital and heterogeneous home bias (EZ-BKK (III)). We set the extent of home bias for investment goods, λ_I, to 0.85, a value consistent with both US data and prior literature. For comparability with the EZ-BKK setting, we retain a total imports share of 8% by setting $\lambda = 0.95$. Our main results continue to hold and are often enhanced.

Appendix D: Indirect inference details

In this section, we describe the details of our indirect inference estimation procedure, along with a robustness exercise.

Appendix D.1: Econometric Methodology

Moment conditions of the Auxiliary Model. Let $m_T(Y_T, \phi)$ be a vector consisting of moment conditions (1)-(16) defined in section Appendix B.1, where $\beta_a^{US} = \beta_a^{RoW} = \beta_a$, and $\varrho^{US} = \varrho^{RoW} = \varrho$.

Estimation. We adopt the following procedure to estimate the vector of model's parameters θ.

1. Estimation using the actual data. Using the observations in the sample Y_T of actual data, we obtain an estimate of the vector ϕ as

$$\hat{\phi}_T = \arg\min_{\phi} Q_T(Y_T, \phi),$$

   where $Q_T(Y_T, \phi) = \left[m_T(Y_T, \phi)' m_T(Y_T, \phi)\right]$.

2. Simulations from the model. For a given value of the model's parameters θ, consider H simulated paths $Y^h(\theta)$, $h = \{1, ..., H\}$ based on independent drawings of ε_t.

3. Estimation using simulated data. For each simulated path, obtain an estimate of the vector of auxiliary parameters, as

$$\tilde{\phi}^h(\theta) = \arg\min_{\phi} Q(Y^h(\theta), \phi).$$

4. Estimation of the model's parameters. Obtain an indirect estimator of θ as the solution of a minimum distance problem:

$$\min_{\theta} \left[\hat{\phi}_T - \frac{1}{H}\sum_{h=1}^{H} \tilde{\phi}^h(\theta)\right]' W \left[\hat{\phi}_T - \frac{1}{H}\sum_{h=1}^{H} \tilde{\phi}^h(\theta)\right],$$

where W is a positive definite weighting matrix, which we set equal to the identity matrix, $W = I$, in all of our estimations. We denote the estimated vector as $\hat{\theta}_T^H(W)$.

Distribution of the estimated structural parameters. The estimator of the vector of structural parameters converges in distribution to

$$\sqrt{T}\left(\hat{\theta}_T^H(\Omega^*) - \theta_0\right) \xrightarrow{d} N\left[0, \Omega(H, W)\right],$$

where the covariance matrix is:

$$\Omega(H,W) = \left(1 + \frac{1}{H}\right)\left(K'J^{-1}WJ^{-1}K\right)^{-1}\left(K'J^{-1}WJ^{-1}\right)M\left(J^{-1}WJ^{-1}K\right)\left(K'J^{-1}WJ^{-1}K\right)^{-1},$$

where

$$K = \frac{\partial^2 Q}{\partial\phi\,\partial\theta'}, \quad J = -\frac{\partial^2 Q}{\partial\phi\,\partial\phi'}, \quad M = \lim_{T\to\infty} Var\left[\sqrt{T}\frac{\partial Q}{\partial\phi} - E\left(\sqrt{T}\frac{\partial Q}{\partial\phi}\right)\right].$$

Gourieroux et al. (1993) propose to estimate the matrix K as

$$\frac{\partial^2 Q}{\partial\phi\,\partial\theta'}\left(y^s\left(\hat{\theta}\right), \hat{\phi}\right).$$

This amounts to taking the numerical derivative of

$$\frac{\partial Q}{\partial\phi}\left(y^s\left(\hat{\theta}\right), \hat{\phi}\right)$$

with respect to the vector of structural parameters θ evaluated at $\hat{\theta}$, where $y^s\left(\hat{\theta}\right)$ is a simulated path of y based on the parameter θ (see page S113 of Gourieroux et al. (1993)). We average the matrices associated to each simulated path s to obtain our estimator of K.

The matrix J can be obtained by taking the negative of the second derivative of the auxiliary model objective function and evaluate it at the observed sample and the associated estimated coefficient, i.e.,

$$\frac{\partial^2 Q}{\partial\phi\,\partial\phi'}\left(Y_T, \hat{\phi}\right).$$

Finally, using the methodology outlined by Gourieroux et al. (1993) (page S112) we consistently estimate the matrix M as

$$\frac{T}{H}\sum_{h=1}^{H}\left(S_h-\bar{S}\right)\left(S_h-\bar{S}\right)$$

with

$$S_h=\frac{\partial Q}{\partial\theta}\left(y_h\left(\phi_{id}\right)\right), \quad \bar{S}=\frac{1}{H}\sum_h S_h,$$

where $y_h\left(\phi_{id}\right)$ is a simulation from the model based on the estimate ϕ_{id} obtained from using $W=I$.

Appendix D.2: Additional results

Alternative weighting schemes. In table D1, we report the estimates for our baseline specification in which Tobin's Q is used to forecast the growth rate of productivity, using alternative weighting schemes for the Rest of the World aggregate. Furthermore, we also present the complete set of parameters of the auxiliary model. The results, presented in table D1, document the strong robustness of our main findings.

Using price-dividend ratios. In this section we perform our indirect inference estimation by replacing Tobin's Q with price-dividend ratio in the predictive regression for productivity in the auxiliary model. Specifically, we define the process for a redundant dividend in the spirit of Bansal and Yaron (2004) as

$$\begin{aligned}\Delta d_{t+1} &= \mu+\lambda\cdot z_t+\tau\left(a_t-a_t^*\right)+\sigma_d\cdot\varepsilon_{d,t+1},\\ \Delta d_{t+1}^* &= \mu+\lambda\cdot z_t^*+\tau\left(a_t-a_t^*\right)+\sigma_d\cdot\varepsilon_{d,t+1}^*,\end{aligned}$$

where ϵ_d and ϵ_d^* are $i.i.d.$ shocks uncorrelated with the other shocks in the economy. We set λ to 13 and σ_d to 0.4, respectively. At the estimated values of the structural parameters reported in Panel A of table D2, this choice of parameters yields the following unconditional moments for the distribution our cash-flows: (i) an unconditional volatility relative to productivity of 14.61, (ii) an autocorrelation of 0.44, (iii) a within country correlation with consumption of 0.43, and (iv) a cross-country correlation of 0.46. These numbers are within the range of what

TABLE D1: Indirect Inference Estimates using Tobin's Q

Panel A: GDP weights

Structural	ρ	σ_z	ρ_{srr}	ρ_{lrr}	τ
Estimates	0.98	0.08	0.27	0.97	0.02
(S.E.)	(0.00)	(0.02)	(0.25)	(0.01)	(0.02)

Auxiliary	$\beta_{NX,a}$	$\beta_{NX,z}$	$\beta_{I,a}$	$\beta_{I,z}$	$\beta_{c,a}$	$\beta_{c,z}$	β	ϱ	ς_z	ϱ_a	ϱ_z
Model	−0.04	0.87	2.04	−21.95	0.44	−0.31	0.35	0.97	0.07	0.22	0.72
Data	−0.08	0.74	5.16	−22.05	0.91	−0.66	0.01	0.91	0.12	0.12	0.77

Panel B: Market cap weights

Structural	ρ	σ_z	ρ_{srr}	ρ_{lrr}	τ
Estimates	0.98	0.08	0.28	0.97	0.02
(S.E.)	(0.00)	(0.02)	(0.17)	(0.01)	(0.02)

Auxiliary	$\beta_{NX,a}$	$\beta_{NX,z}$	$\beta_{I,a}$	$\beta_{I,z}$	$\beta_{c,a}$	$\beta_{c,z}$	β	ϱ	ς_z	ϱ_a	ϱ_z
Model	−0.04	0.90	2.05	−21.35	0.43	−0.29	0.33	0.97	0.06	0.23	0.65
Data	−0.08	0.74	5.13	−21.31	0.81	−0.22	0.01	0.93	0.12	0.62	0.79

Panel C: Equal weights

Structural	ρ	σ_z	ρ_{srr}	ρ_{lrr}	τ
Estimates	0.98	0.08	0.28	0.97	0.02
(S.E.)	(0.01)	(0.05)	(0.32)	(0.06)	(0.07)

Auxiliary	$\beta_{NX,a}$	$\beta_{NX,z}$	$\beta_{I,a}$	$\beta_{I,z}$	$\beta_{c,a}$	$\beta_{c,z}$	β	ϱ	ς_z	ϱ_a	ϱ_z
Model	−0.04	0.93	2.06	−22.16	0.43	−0.26	0.32	0.97	0.06	0.23	0.06
Data	−0.08	0.77	4.68	−22.17	0.81	−0.43	0.01	0.89	0.12	0.56	0.82

Notes. Each panel refers to one of the three alternative weighting schemes that we have adopted for the Rest of the World aggregate. In each panel, the top sub-panel (Structural) reports the estimates for each element of the vector of structural parameters (θ) with the associated standard errors in parenthesis. The bottom sub-panel (Auxiliary) reports the coefficients of the auxiliary model. The row labeled "Model" shows the estimates of the auxiliary model associated to the point estimates of the structural parameters reported in the top panel. The row labeled "Data" reports the estimates of the auxiliary model obtained from actual data.

we typically find in the data (see for example Bansal and Lundblad (2002)). We then obtain the price-dividend ratios associated to these cash flows, by using the equilibrium stochastic discount factor to solve the corresponding Euler equations:

$$PD_t = E_t[M^X_{t+1}(1 + PD_{t+1})e^{\Delta d_{t+1}}], \quad PD^*_t = E_t[M^Y_{t+1}(1 + PD^*_{t+1})e^{\Delta d^*_{t+1}}].$$

TABLE D2: Indirect Inference Estimates using p/d ratios

Panel A: GDP weights

Structural	ρ	σ_z	ρ_{srr}	ρ_{lrr}	τ
Estimates	0.99	0.26	0.24	0.99	0.03
(S.E.)	(0.00)	(0.05)	(0.31)	(0.00)	(0.15)

Auxiliary	$\beta_{NX,a}$	$\beta_{NX,z}$	$\beta_{I,a}$	$\beta_{I,z}$	$\beta_{c,a}$	$\beta_{c,z}$	β	ϱ	ς_z	ϱ_a	ϱ_z
Model	−0.18	1.18	5.06	−22.06	0.20	−1.05	0.00	0.98	0.28	0.25	0.99
Data	−0.08	0.74	5.16	−22.05	0.91	−0.66	0.01	0.91	0.12	0.12	0.77

Panel B: Market cap weights

Structural	ρ	σ_z	ρ_{srr}	ρ_{lrr}	τ
Estimates	0.99	0.26	0.30	0.99	0.03
(S.E.)	(0.01)	(0.11)	(0.25)	(0.04)	(0.02)

Auxiliary	$\beta_{NX,a}$	$\beta_{NX,z}$	$\beta_{I,a}$	$\beta_{I,z}$	$\beta_{c,a}$	$\beta_{c,z}$	β	ϱ	ς_z	ϱ_a	ϱ_z
Model	−0.18	1.14	5.08	−21.35	0.21	−1.04	0.00	0.98	0.28	0.31	0.99
Data	−0.08	0.74	5.13	−21.31	0.81	−0.22	0.01	0.93	0.12	0.62	0.79

Panel C: Equal weights

Structural	ρ	σ_z	ρ_{srr}	ρ_{lrr}	τ
Estimates	0.99	0.26	0.34	0.99	0.03
(S.E.)	(0.01)	(0.11)	(0.69)	(0.02)	(0.14)

Auxiliary	$\beta_{NX,a}$	$\beta_{NX,z}$	$\beta_{I,a}$	$\beta_{I,z}$	$\beta_{c,a}$	$\beta_{c,z}$	β	ϱ	ς_z	ϱ_a	ϱ_z
Model	−0.16	1.19	4.81	−22.32	0.22	−1.16	0.00	0.98	0.28	0.34	0.99
Data	−0.08	0.77	4.68	−22.17	0.81	−0.43	0.01	0.89	0.12	0.56	0.82

Notes. Each panel refers to one of the three alternative weighting schemes that we have adopted for the Rest of the World aggregate. In each panel, the top sub-panel (Structural) reports the estimates for each element of the vector of structural parameters (θ) with the associated standard errors in parenthesis. The bottom sub-panel (Auxiliary) reports the coefficients of the auxiliary model. The row labeled "Model" shows the estimates of the auxiliary model associated to the point estimates of the structural parameters reported in the top panel. The row labeled "Data" reports the estimates of the auxiliary model obtained from actual data.

When estimating the auxiliary model on simulated data, we replace Tobin's Q with these price-to-dividend ratios. We then apply the same empirical strategy described in both main text ad this section of the appendix. The results are reported in table D2 and they are consistent with those obtained under our benchmark estimation exercise.