Target Date Funds and International Capital Flows*

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Abstract

Target date funds (TDFs) are investment products designed based on the life-cycle theory to provide exposure to risky assets conditional on investors' age. Even though life-cycle portfolio choice models do not distinguish between different subcategories of risky assets, we document that in practice, TDFs adopt and maintain rigid allocation weights to domestic and foreign equities. Our main finding is that TDFs implement contrarian rebalancing trades. These trades offset 53% of the mechanical allocation changes caused by realized differences in returns between domestic and foreign equities within the same quarter. TDFs are organized as funds-of-mutual-funds and their holdings account for 10% of the total assets managed by U.S. foreign equity mutual funds in 2022. We show that TDFs' contrarian rebalancing trades have three implications for international capital markets. First, the growth of TDFs significantly changes the prevalent positive flow-performance sensitivity among mutual funds: foreign equity mutual funds with higher TDF ownership experience outflows when foreign equity outperforms domestic equity. Second, the returns on foreign stocks with higher TDF ownership co-move more with the U.S. equity market and less with the foreign equity market. Finally, at an aggregate level, currencies affected more by TDF rebalancing flows appreciate more when the U.S. stock market delivers higher returns.

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1 Introduction

Target date funds (TDFs) are investment products designed based on the life-cycle theory to gradually adjust the allocation to risky assets depending on investors' age (Viceira, 2001; Campbell and Viceira, 2002; Cocco, Gomes, and Maenhout, 2005; Gomes and Michaelides, 2005; Dahlquist, Setty, and Vestman, 2018). As individual investors age, TDFs follow a pre-specified glide path that reduces the allocation to equity and increases the allocation to fixed income. TDFs were designated as a qualified default investment product in the U.S. by the 2006 Pension Protection Act, which led to the widespread adoption of TDFs: in 2020, 86% of the 401(k) retirement plans included TDFs and 59% of the participants held TDFs (Investment Company Institute, 2022). The assets under management of TDFs increased to $1.5 trillion in 2022, and together with other investment products that follow the life-cycle theory, they jointly managed $4.7 trillion in 2022.[1]

Life-cycle portfolio choice models typically focus on the optimal allocation between a risky and a riskless asset, taking the investor's age into account. Accordingly, Parker, Schoar, and Sun (2023) show that TDFs frequently rebalance between equity and fixed income to maintain an equity allocation that is calibrated to an individual's retirement date. In this paper, we focus on a different dimension: domestic versus foreign equity holdings. We show that TDFs frequently rebalance between these two subcategories of equities to maintain stable weights. In fact, we document that at least 80% of TDFs explicitly report separate target weights for U.S. equities and international equities in their prospectuses. These separate target weights and the substantial contrarian rebalancing are at odds with life-cycle portfolio choice models that do not distinguish between different subcategories within equities. TDFs have become major owners of foreign equities. We show that their rebalancing trades have significant implications for the flow-performance sensitivity of the underlying mutual

[1] In our analysis, we focus on TDFs, but their asset allocation decisions also proxy for the rebalancing behavior and impact of other life-cycle investment products, such as balanced funds and collective investment trusts, that closely follow pre-defined allocation weights.

funds, the comovement of foreign stocks, and the ex-post returns on the respective currencies.

To examine the impact of TDFs on international capital flows, we use data from the CRSP Mutual Fund Database on all 705 TDFs and their underlying holdings of mutual funds over the 2011–2022 period. We also hand-collect data from TDFs' prospectuses on their target asset allocation. During our sample period, TDFs have experienced rapid growth as a retirement investment product. The share of TDFs' assets as a percentage of the total U.S. foreign equity mutual fund holdings has increased from 3.5% in 2011 to 10.8% in 2022. On average, they have maintained a relatively stable allocation to foreign equities of 21% of the total portfolio. Through their mutual funds, TDFs gain exposure to $5,322$ foreign stocks listed in 51 developed and emerging market countries.

TDFs actual weights to foreign and domestic equity will fluctuate when the realized returns on these equity subcategories differ. Our first research question examines how TDFs respond to these "mechanical" changes in portfolio weight. We posit three hypotheses on the rebalancing decisions of TDFs. First, the *Inertia Hypothesis* stems from life-cycle portfolio choice models that focus only on the allocation to equity versus fixed income. This hypothesis predicts that TDFs will not rebalance their portfolio to revert the changes in asset allocation weights caused by differences in returns between domestic and foreign equities. Second, the *Rebalancing Hypothesis* originates from the observation that many TDFs report separate target weights for the equity subclasses. This hypothesis predicts that TDFs will frequently rebalance to maintain a portfolio composition of domestic and foreign equities that closely resembles their target weights. Third, the *Changing Target Hypothesis* predicts that TDFs will absorb the mechanical changes in portfolio weights by adjusting the target asset allocation weights instead of rebalancing the portfolio. If domestic equities outperform foreign equities, TDFs will increase the target weight of domestic equity.

To test these hypotheses, we use two measures of TDF rebalancing trades. First, the rebalancing flow measure follows Parker, Schoar, and Sun (2023), and captures the difference between the total

realized trades in foreign equity and the hypothetical proportional-flow-driven trades in foreign equity. This measure acknowledges that part of the total TDF trades are due to aggregate flows into or out of the TDF, and assumes that the flow-driven trades keep the foreign versus domestic equity weights the same. Second, the rebalancing weight measure is based on Camanho, Hau, and Rey (2022) and captures the difference between the actual foreign equity weight and the counterfactual mechanical weight if the TDF did not make any trades. The two measures differ in how they treat TDF flows, but they still display a correlation of 0.58 and provide the same conclusions.

Our results support the *Rebalancing Hypothesis* and we observe limited inertia in the TDF rebalancing trades. We show that the foreign equity rebalancing trades of TDFs respond similarly to the return difference between foreign equity and domestic equity as to the return difference between foreign equity and fixed income. We first construct a predicted flow measure, assuming TFDs fully rebalance to offset any changes in foreign equity weights due to realized return differences. We find that TDFs implement 53% of the predicted rebalancing flow between foreign and domestic equities in the same quarter. Similarly, they implement 72% of the predicted flow between foreign equities and fixed income. A five percentage point difference between the benchmark returns on foreign and domestic equity is associated with a 0.34% rebalancing reduction in the weight on foreign equities. Given that the aggregate TDF assets were around $1.50 trillion in 2022, this coefficient implies that a five percentage point difference between the returns on foreign and domestic equity results in $5.03 billion outflows from the TDF foreign equity holdings in the same quarter. These magnitudes are obtained after accounting for the rebalancing between fixed income and equity.

The evidence we present is not consistent with the *Changing Target Hypothesis*. Using the subsample of 363 TDFs with available target asset allocation data (representing 80% of the assets under management), we find that the TDF target allocation to foreign equities exhibits very few changes over time. Importantly, target weights for domestic versus foreign equity do not respond to

the differences in returns between foreign and domestic equity or between foreign equity and fixed income, either in the same or in the previous quarter.

Returns on foreign equity consist of two components: the local currency equity returns and the currency returns. Therefore, we examine the drivers behind the TDFs' rebalancing trades in foreign equity by looking at these two components separately. We find that TDFs' rebalancing trades display a similar sensitivity to both local foreign equity returns as well as currency returns, suggesting that foreign equity mutual funds held by the TDFs do not fully hedge against exchange rate risk. Moreover, the results suggest that the TDFs do not hedge against exchange rate movements on the aggregate portfolio level either.[2]

In sum, our main finding is that TDFs frequently implement contrarian rebalancing trades between domestic and foreign equities. Through their growing foreign equity mutual fund holdings, TDFs have become major international investors and their rebalancing trades could have implications for international capital flows and markets. In the second part of our analysis, we analyze three consequences of the TDF rebalancing activity.

First, we show that TDF contrarian rebalancing flows affect the flow-performance sensitivity of foreign equity mutual funds. On average, domestic and foreign equity mutual fund investors display positive flow-performance sensitivity; they direct more flows to the best-performing mutual funds and asset classes (e.g., Sirri and Tufano, 1998; Froot, O'Connell, and Seasholes, 2001; Frazzini and Lamont, 2008; Jotikasthira, Lundblad, and Ramadorai, 2012). However, the flows to foreign equity mutual funds with higher TDF ownership depend on the relative performance of foreign versus domestic equity, consistent with the TDFs' contrarian rebalancing trading. Indeed, we show that these mutual funds experience a negative flow-relative-performance sensitivity. For instance, our estimates suggest that a foreign equity mutual fund that manages assets only from TDF investors would face an

[2]Our findings are in line with the evidence in Hau and Rey (2004) that investors sell foreign equity in response to the appreciations of the foreign equity market and foreign currency.

outflow equal to −2.26% of its assets under management when foreign equity outperforms domestic equity by five percentage points. The total outflows are even larger as they are significant not only in the contemporaneous quarter, but also with a one-quarter lag.

Second, we analyze the impact of the increasing TDF ownership on foreign equity markets. Even though TDFs act as funds-of-mutual-funds and do not invest directly in securities, their contrarian rebalancing flows to the underlying mutual funds can influence the comovement of the foreign stocks owned by these mutual funds. TDFs have become important international investors as they (indirectly) own on average 0.57% of the market capitalization in foreign countries during our sample period, and there are many countries where TDFs own more than 1% of the total market capitalization. The ownership stake of TDFs in foreign stocks is comparable with their stake in domestic stocks (Parker, Schoar, and Sun, 2023) and the total share will be higher if we account for similar life-cycle investment products. We find that when the TDF ownership of a foreign stock increases, the return of this stock co-moves significantly more with the return on the U.S. domestic equity market and less with the return on the foreign equity market. Thus, TDF ownership affects the comovement of foreign stocks and this cannot be explained by the overall ownership of U.S. foreign equity mutual funds.

Third, we explore the aggregate implications of TDF contrarian rebalancing trades by studying the relation between TDF flows and currency returns. When the U.S. stock market delivers higher returns or the USD appreciates, TDFs respond by purchasing foreign equities through the underlying mutual funds. These positive aggregate inflows from TDFs to a given foreign country can lead to an appreciation of the local currency, and vice versa for outflows. Based on a sample of TDF holdings in 41 countries and 35 currencies, we find that when a country receives more inflows from the TDFs, its currency appreciates more relative to the USD. A one standard deviation increase in the aggregate TDF rebalancing inflow, which corresponds to an inflow of $0.17 billion in a given currency in the

previous quarter, is associated with a 0.29% appreciation of the foreign currency relative to the USD.

We extend our exchange rate impact analysis by implementing the granular instrumental variables (GIV) approach (Gabaix and Koijen, 2020, 2022). The GIV analysis isolates idiosyncratic shocks of TDF flows and uses them to examine how much the exchange rates change in response to TDF rebalancing decisions. Based on this methodology, we find a currency supply elasticity that ranges from 0.21 to 0.32. In other words, a 1% effective quarterly foreign exchange rate appreciation is associated with a net currency demand shock of 0.21%–0.32% of the average aggregate TDF positions in a currency.

In summary, we document that TDFs have an increasingly important role in international financial markets. TDFs frequently adjust their portfolio to counterbalance the changes in the actual allocation weights and maintain a portfolio composition of foreign versus domestic equity that closely resembles the target weights. The TDF assets under management represent a significant fraction of the U.S. foreign equity mutual fund holdings and through their contrarian rebalancing trades TDFs affect the risk-return characteristics of foreign stocks and currencies.

Related literature First, our paper relates to the literature on the impact of life-cycle funds on portfolio choice and investor behavior. The wide adoption of TDFs provides many benefits such as increased diversification and reduced exposure to idiosyncratic risks (e.g., Chalmers and Reuter, 2020; Mitchell and Utkus, 2022; Parker, Schoar, Cole, and Simester, 2022), but also has shortcomings in the rigid asset allocation and high expenses (e.g., Shoven and Walton, 2021; Gomes, Michaelides, and Zhang, 2022; Brown and Davies, 2023). Parker, Schoar, and Sun (2023) show that TDFs implement contrarian rebalancing strategies between stocks and bonds. Our contribution is to show that the adoption of TDFs as a default retirement product in the U.S. has spillovers to other countries. TDFs rebalance between domestic and foreign equity markets. We show that these rebalancing flows affect both international stock return comovements and currency returns.

Second, prior literature has examined the role of mutual funds in international capital markets (e.g., Hau and Rey, 2008; Jotikasthira, Lundblad, and Ramadorai, 2012; Raddatz and Schmukler, 2012; Curcuru, Thomas, Warnock, and Wongswan, 2014). Active decisions of pension plan members also influence equity markets and exchange rates (Da, Larrain, Sialm, and Tessada, 2018; Aldunate, Da, Larrain, and Sialm, 2023), but most of the defined contribution plan participants rarely adjust their portfolio (Sialm, Starks, and Zhang, 2015). Our contribution is to show that even if the ultimate asset owners are inert, packaging multiple mutual funds in one bundled product, such as a TDF, can alter the flow-performance sensitivity of the underlying mutual funds and affect their foreign equity holdings.

Third, we also contribute to the literature on the relation between financial flows and exchange rates (Hau and Rey, 2006; Hau, Massa, and Peress, 2010; Koijen and Yogo, 2020; Camanho, Hau, and Rey, 2022; Jiang, Richmond, and Zhang, 2022). We show that on aggregate, TDFs foreign equity rebalancing creates price pressure in currency markets and significantly affects realized exchange rate changes. Finally, currency risk is an important factor that shapes global portfolios (Campbell, Serfaty-De Medeiros, and Viceira, 2010; Lustig, Roussanov, and Verdelhan, 2011; Maggiori, Neiman, and Schreger, 2020). Our results suggest that both TDFs and their underlying mutual funds do not fully hedge against exchange rate risk, as the TDFs' contrarian rebalancing trades respond to both currency returns as well as the local currency denominated equity returns.

2 Institutional Background and Data on Target Date Funds

2.1 Target Date Funds Asset Allocation

Target date funds (TDFs) are investment products that were designated by the 2006 Pension Protection Act as an eligible default investment option in 401(k) retirement plans. TDFs are organized as funds-of-funds that invest in equity and fixed income mutual funds. Their asset

allocation is based on life-cycle portfolio choice models and depends on the age of participants. As participants age over time, TDFs gradually rebalance their asset allocation from equities to bonds using a pre-defined glide path.

We obtain data on TDFs from the CRSP Mutual Fund Database over the 2011–2022 period.[3] Figure 1 Panel A shows that TDFs assets increased to $1.5 trillion at the end of 2022. However, TDFs are just one type of product that adopts a life-cycle investment strategy. Other investment products, such as balanced funds and collective investment trusts, also closely follow life-cycle models.[4] Figure A.1 in the Online Appendix follows Parker, Schoar, and Sun (2023) and shows that the total assets under management of these life-cycle-model-based products increased from $0.2 trillion in 2002 to $4.7 trillion in 2022. When discussing the implications of our paper, we consider TDFs as a representative proxy for the asset allocation policy and investment decisions of all of these types of life-cycle-model-based products. The advantage of focusing on the sample of TDFs is that the CRSP CUSIP codes enable us to identify exactly the underlying mutual funds and ultimately the individual stocks and currencies in the TDF portfolios.

Table 1 presents summary statistics on the sample of TDFs. TDFs are usually organized in a series of multiple funds-of-funds that match the different retirement ages of the members of a retirement plan. Our sample contains TDFs managed by 72 unique fund families. Since one fund family can establish multiple series of TDFs, we collect data on 96 series of TDFs.[5] On average, every series contains 7.3 TDFs so our final sample has 705 TDFs. Table 1 shows that one TDF allocates capital on average to 15.8 mutual funds and these mutual fund holdings account for almost 96% of the TDF assets. TDFs can invest in active and passive mutual funds.

[3]The analysis starts in 2011 as the CRSP dataset coverage was limited before this year and reported the CUSIP identifiers for less than 40% of the foreign equity holdings.

[4]Balanced funds invest in both equities and fixed income with constant pre-specified allocation weights. Collective investment trusts are customized pooled investment products that brokers provide to large institutional investors and retirement plans. In addition to TDFs as a standard product, some large employers may negotiate with providers for a customized plan with collective investment trusts, with similar age-dependent glide paths.

[5]We manually cleaned the TDF series name and manager name based on information from SEC. For example, Vanguard manages two series of TDFs: Target Retirement Fund and Institutional Target Retirement Fund.

Asset allocation models based on the life-cycle theory distinguish only between risky equity assets and safer fixed income assets. These models do not differentiate between different subcategories of risky assets, such as domestic and foreign equities. However, in practice, the vast majority of TDFs distinguish between domestic U.S. equity, foreign equity, and fixed income in their prospectuses. We hand-collect target asset allocation data from the TDF's prospectuses that are uploaded on the SEC website and confirm that most TDFs distinguish between domestic U.S. equity, foreign equity, and fixed income when reporting their target glide path by asset class.[6] The target allocation data is available for 363 TDFs managed by 25 fund families. In terms of assets under management, this subsample with target asset allocation data represents 80% of all assets managed by TDFs in our sample. We use the CRSP Mutual Fund dataset to obtain information on the actual asset allocation of all TDFs. The CRSP Mutual Fund Database provides style and objective codes, which enable us to classify mutual funds as domestic equity, foreign equity, and fixed income funds.[7]

Figure 1 Panel A shows that around 80% of total TDFs assets under management is in a TDF with an explicit target weight to foreign equity in their glide path. These TDFs had $1.14 trillion of assets at the end of 2022. The remaining TDFs either do not explicitly state their target weight to foreign equity or do not provide information on their target allocation in the prospectuses. We focus on the distinction between foreign and domestic equities because it is widely adopted among the TDFs, while Online Appendix Figure A.2 shows that only 13% of TDFs decompose further the target weight to foreign equities into emerging and developed markets.[8]

Figure 1 also presents the asset allocation of the TDFs that explicitly distinguish between domestic and foreign equity. Panel B shows that TDFs have a relatively stable target policy over

[6]We use the prospectus publication date as a date when the target allocation is adopted. If the prospectus provides an effective date for the target asset allocation policy that differs from the publication date, we use the effective date.

[7]Following Parker, Schoar, and Sun (2023), we drop underlying mutual funds that are classified as Others (O) and Mixed funds (M), as well as those without any fund information. The mutual funds that we drop account for 8% of the market value of all underlying funds owned by TDFs.

[8]The significant drop in the proportion of TDFs distinguishing between developed and emerging international equities in 2014Q2 displayed in Online Appendix Figure A.2 is because Fidelity stopped making this distinction.

time and have gradually increased their target allocation to foreign equity at the expense of domestic equity. Panel C shows that the actual asset allocation policy of TDFs closely follows the target weights, which suggests that TDFs will frequently rebalance their portfolio to match the target weights to domestic and foreign equities. We will formally test this relation in Section 3.

2.2 Target Date Funds Rebalancing Measures

Our data includes quarterly holding values of TDFs' positions in mutual funds. Based on this data, we construct two measures to capture the rebalancing decisions of TDFs. First, we construct a rebalancing flow measure($RebalFlow_q^{FE}$), which is based on a TDF's trades of foreign equity mutual funds, corrected for the trades induced by aggregate flows into or out of the TDF. To estimate these so-called flow-driven trades, we assume that these flows are allocated to the asset subclasses proportionally so that weights remain the same after the flow-induced trades. Any additional trades thus stem from rebalancing.

To alleviate this assumption, we also construct a second measure of TDF rebalancing activity, which is based on the weight of foreign equity in the TDF portfolio. The so-called rebalancing weight measure ($RebalWeight_q^{FE}$) captures the extent to which the actual weight deviates from the counterfactual weight of foreign equity, based on the previous quarter's holdings if the TDF would not make any trades in the current quarter.

More specifically, $RebalFlow_q^{FE}$ captures the rebalancing flow to foreign equity scaled by TDF's assets under management at the end of the previous quarter. This measure extends the Parker, Schoar, and Sun (2023) analysis to include foreign equities. The foreign equity rebalancing flow of TDF k is calculated as the difference between total foreign equity trade and flow-driven trade.

$$RebalFlow_{k,q}^{FE} = \frac{TotalTrade_{k,q}^{FE} - FlowDrivenTrade_{k,q}^{FE}}{TNA_{k,q-1}}. \tag{1}$$

The total foreign equity trade of TDF k in quarter q aggregates all trades in its underlying foreign equity mutual funds. It captures the change in the total value of TDF holdings (HV) beyond the changes in holdings value that stem from realized returns on these mutual funds over that quarter:

$$TotalTrade_{k,q}^{FE} = \sum_{i=1}^{N_{k,q}^{FE}} (HV_{i,k,q} - HV_{i,k,q-1} \times (1 + R_{i,q})), \tag{2}$$

where $N_{k,q}^{FE}$ denotes the number of foreign equity mutual funds owned by TDF k in quarter q. $HV_{i,k,q}$ is the value of the holdings of TDF k in the underlying mutual fund i in quarter q. $R_{i,q}$ is the return of mutual fund i during quarter q.

The flow-driven trade assumes that the TDF allocates any net dollar in or outflows to the TDF proportionally to the underlying asset classes based on the portfolio weights at the end of the previous quarter:

$$FlowDrivenTrade_{k,q}^{FE} = (TNA_{k,q} - TNA_{k,q-1} \times (1 + R_{k,q})) \times \omega_{k,q-1}^{FE}, \tag{3}$$

where $TNA_{k,q}$ is the total net assets of TDF k at quarter q. $R_{k,q}$ is the quarterly return of TDF k. $\omega_{k,q-1}^{FE}$ is the actual foreign equity weight in the total portfolio of TDF k at quarter $q-1$.

The main $RebalFlow_q^{FE}$ measure is constructed based on a three-asset setting, so the rebalancing flow depends on the returns on foreign equity, domestic equity, and fixed income.[9] As a robustness test, we construct an alternative rebalancing measure, called the residual rebalancing flow measure $ResidRebalFlow_q^{FE-DE}$. Here, we first calculate the hypothetical rebalancing flow assuming 100% reversion of the mechanical changes in weights between the total equity holdings (domestic and foreign equity) and the fixed income holdings.

The calculation of $HypotRebalFlow_{k,q}^{FE-FI}$ starts from the setting of a two-asset framework with

[9]Note that $\omega_{k,q-1}^{FE}$ is the weight of foreign equity in the total TDF portfolio that includes foreign equity, domestic equity and fixed income.

equity and fixed income. We compute the total trade to equity ($TotalTrade^{E}_{k,q}$) from Equation (2) where $N^{E}_{k,q}$ now denotes all equity mutual funds owned by TDF k in quarter q. The flow-driven trade in equity ($FlowDrivenTrade^{E}_{k,q}$) is calculated from Equation (3) where $\omega^{E}_{k,q-1}$ now denotes the total weight of equity. Lastly, we assume the TDFs re-allocate the rebalancing flows to equity proportionally to foreign equity and domestic equity based on their relative allocation weight at the end of the previous quarter:

$$HypotRebalFlow^{FE-FI}_{k,q} = \left(\frac{TotalTrade^{E}_{k,q} - FlowDrivenTrade^{E}_{k,q}}{TNA_{k,q-1}} \right) \times \frac{\omega^{FE}_{k,q-1}}{\omega^{E}_{k,q-1}}. \tag{4}$$

The residual rebalancing flow measure captures any rebalancing flow in excess of this hypothetical rebalancing flow:

$$ResidRebalFlow^{FE-DE}_{k,q} = RebalFlow^{FE}_{k,q} - HypotRebalFlow^{FE-FI}_{k,q}. \tag{5}$$

Our measurement of the $ResidRebalFlow^{FE-DE}_{q}$ is conservative as it relies on the assumption that TDFs rebalance to offset 100% of the mechanical changes in weights of equity and fixed income, while Parker, Schoar, and Sun (2023) show that TDFs rebalance only 60% to 70% this amount.

These two rebalancing flow measures, $RebalFlow^{FE}_{q}$ and $ResidRebalFlow^{FE-DE}_{q}$, make assumptions about how the flows to TDFs are allocated. To avoid such assumptions, we also use a second rebalancing measure based on portfolio weights rather than flows. This measure, $RebalWeight^{FE}_{k,q}$, follows the literature on portfolio rebalancing (e.g., Curcuru, Thomas, Warnock, and Wongswan, 2011; Camanho, Hau, and Rey, 2022) and is defined as the deviation of the actual foreign equity weight at quarter q from the counterfactual mechanical weight at quarter q if the TDF did not make any trades. The mechanical weight assumes that the TDF does not trade so the weight invested in foreign equities in quarter q is determined mechanically by the weight invested in foreign equities in

quarter $q-1$ and the realized relative return of this asset class from $q-1$ to q.

$$RebalWeight_{k,q}^{FE} = \omega_{k,q}^{FE} - \omega_{k,q-1}^{FE}\left(\frac{1+\hat{R}_{k,q}^{FE}}{1+\hat{R}_{k,q}}\right), \tag{6}$$

where $\hat{R}_{k,q}^{FE}$ is the aggregate return of all N^{FE} foreign equity mutual funds owned by TDF k assuming that the weights across these funds remain the same. It is calculated as $\hat{R}_{k,q}^{FE} = \sum_{i=1}^{N_{k,q}^{FE}} \omega_{i,k,q-1}^{FE} R_{i,q}^{FE}$. The aggregate total return of the TDF $\hat{R}_{k,q}$ is calculated as a weighted average of the returns of all N underlying mutual funds $\hat{R}_{k,q} = \sum_{i=1}^{N_{k,q}} \omega_{i,k,q-1} R_{i,q}$. Intuitively, when $RebalWeight_q^{FE}$ equals zero, the TDF does not trade any foreign equities. When $RebalWeight_q^{FE}$ is positive (negative), the TDF buys (sells) more foreign equities during quarter q.

As we have three categories of assets, we decompose the $RebalWeight_{k,q}^{FE}$ into $RebalWeight_{k,q}^{FE-FI}$ and $RebalWeight_{k,q}^{FE-DE}$ in a similar way. $RebalWeight_{k,q}^{FE-FI}$ is defined as the same rebalancing weight of foreign equity and domestic equity adjusted against the fixed income, and $RebalWeight_{k,q}^{FE-DE}$ is the relative rebalancing weight of foreign equity adjusted within the asset class of equity. We can obtain $RebalWeight_{k,q}^{FE-DE}$ directly as follows:

$$RebalWeight_{k,q}^{FE-DE} = \frac{\omega_{k,q}^{FE}}{\omega_{k,q}^{E}} - \frac{\omega_{k,q-1}^{FE}}{\omega_{k,q-1}^{E}}\left(\frac{1+\hat{R}_{k,q}^{FE}}{1+\hat{R}_{k,q}^{E}}\right). \tag{7}$$

Table 1 Panel D shows that the average rebalancing flow to foreign equities is 0.11% of assets, which implies that TDFs were on average purchasing foreign equities for rebalancing purposes during the sample period. The standard deviation of 1.58 implies that TDFs can experience substantial shocks to the asset allocation from return differences in the underlying asset classes and rebalance a high proportion of their TNAs. If we exclude any rebalancing due to fixed income returns, the average residual rebalancing flow between domestic and foreign equities is 0.27% which is even higher as domestic equities substantially outperformed foreign equities during our sample period.

If TDFs actively rebalance towards fixed target weights, the outperformance of domestic equity would indeed imply a flow into foreign equity. The average rebalancing weight to foreign equities (0.82%) and the standard deviation (2.07%) are also evidence for TDFs' rebalancing behaviors. The correlation between the $RebalFlow^{FE}_{k,q}$ and $RebalWeight^{FE}_{k,q}$ is 0.58, suggesting that both measures can be applied to the TDFs. The main difference between the two measures is that $RebalWeight^{FE}_{k,q}$ does not rely on assumptions about aggregate TDF flows.

2.3 Target Date Funds International Equity Holdings

To analyze the impact of TDFs on international financial markets, we collect data on their foreign equity holdings. Since TDFs are organized as funds-of-funds, they do not invest directly in securities but rather gain exposure to stocks and bonds indirectly by allocating capital to mutual funds. Over the last decades, TDFs have experienced rapid growth, which is reflected in their mutual fund holdings. Online Appendix Figure A.3 shows that TDFs are major owners of foreign equities and the share of TDF assets as a percentage of the total U.S. foreign equity mutual fund holdings has increased from 3.4% in 2011 to 9.8% in 2022.[10]

Table 2 Panel A reports summary statistics on U.S. mutual funds investing in foreign equities. The CRSP Mutual Fund Database provides quarterly data on 2,506 U.S. foreign equity mutual funds. Only 386 of them have ever been owned by TDFs. We analyze separately the subsample of 6,875 foreign equity mutual-fund-quarter observations that are owned by TDFs and the subsample of 56,800 foreign equity mutual-fund-quarter observations without any TDF ownership. For foreign equity mutual funds that have TDF ownership, the average (median) ownership share of TDFs is 21.5% (5.1%). Mutual funds that receive capital from TDFs are almost ten times larger in terms of

[10]This figure presents an abnormal drop in the TDF assets in 2015Q2 which is due to missing data in the CRSP Mutual Fund holdings in this quarter. For instance, several Vanguard target date funds (with target years 2010, 2015, 2020, 2030, 2035, 2040, and 2045) have no holdings data in this quarter. The total foreign equity mutual fund holdings of these Vanguard TDFs account for 1.16% in 2015Q1 and 1.42% in 2015Q3, which can entirely explain the 1.12% abnormal drop in 2015Q2. (Parker, Schoar, and Sun, 2023) also note that 2015Q2 quarter has a lower coverage of TDFs holdings data.

assets under management ($11.46 vs $1.17 billion) and belong to larger fund families. These funds maintain a similar position in cash and charge around 20 basis points lower expense ratio than funds without TDF ownership.

We use the CRSP Mutual Fund Database to collect information on the foreign stocks owned by the TDFs through their mutual fund holdings. We match 77% of CRSP mutual fund holdings data in terms of market value with stock returns and financial data at the firm level from the Compustat Global and North America Database.[11] For cross-listed stocks, we use the returns, price, and trading volume from the main exchange, which is defined as the exchange where the stock has the highest cumulative trading volume and longest trading history.[12]

Table 2 Panel B presents summary statistics of 5,322 foreign stocks that have ever been owned by TDFs between 2011Q1 and 2022Q4.[13] For these stocks, we construct a panel dataset of 144,284 stock-quarter observations. We further split them into stocks with above-median and below-median TDF ownership. For stocks with high TDF ownership, the average TDF ownership is 0.58%, which is close to the 0.87% average TDF stake in U.S. domestic stocks with high TDF ownership (Parker, Schoar, and Sun, 2023). Thus, although TDFs are a U.S. retail retirement innovation, their importance for foreign stocks is comparable to their importance for domestic stocks.

In our analysis, after examining the rebalancing decisions of TDFs into foreign equity, we analyze the potential aggregate consequences of their trading behavior in international markets. As a first step, we show that overall, TDFs have become major capital providers to U.S. foreign equity mutual

[11] In the CRSP dataset, 97% of the foreign equity holdings have a CUSIP code. We use Capital IQ to link CRSP global CUSIP identifiers to Compustat GVKEY identifiers.

[12] For example, Nokia is listed on the SWX Swiss Exchange (with currency CHF), Helsinki Exchange (EUR), German IBIS Exchange (EUR), Milan Exchange (EUR), Prague Exchange (CZK), Sofia Exchange (EUR), Stockholm Exchange (SEK), Vienna Exchange (EUR), and NYSE Euronext Paris Exchange (EUR). In this case, we classify the Helsinki Exchange (EUR) as the main exchange because Nokia has the highest cumulative trading volume and longest trading history on this exchange.

[13] Our sample excludes foreign stocks that have never been owned by TDFs. Online Appendix Table A.4 reports a robustness test where we expand the sample by including foreign stocks that have ever been owned by U.S. foreign equity mutual funds during the sample period, but not by TDFs. We also drop stocks of firms headquartered in the U.S. as most TDF holdings of these firms come from domestic equity funds.

funds and through them, they have become important international investors. Figure 2 presents the dispersion and ranges of TDF ownership on stock level and country level.[14] On a stock level, Panel A shows that the average ownership stake of TDFs increases from 0.15% in 2011 to 0.51% in 2022 for a given foreign firm, but there are firms with 1.5% TDF ownership. Based on Panel B, the importance of TDFs as international investors has increased over time and they own on average 0.57% of the market capitalization in foreign countries. In several countries, such as Switzerland, Sweden, and the Netherlands, TDFs own more than 1% of the total market capitalization. Panels C and D highlight the importance of TDFs as investors in U.S. foreign equity mutual funds. The TDF ownership share as a percentage of the total market cap owned by U.S. mutual funds on a country level has increased from 3.5% in 2011 to 10.8% in 2022. In Online Appendix Figure A.4, we show that the TDF ownership of foreign equities on a country level has also increased as a percentage of GDP, which is important for our analysis of the relation between TDF flows and currency markets.

3 TDFs Asset Allocation and Portfolio Rebalancing

Our main empirical analysis consists of two parts. First, in this section, we examine the rebalancing behavior of TDFs into foreign equities. Then, in Sections 4, 5 and 6, we test three potential implications of their ytrading behavior for mutual funds flow-performance sensitivity, international equity market comovements and exchange rate changes.

This section tests three hypotheses on whether and how TDFs address the mechanical changes in portfolio weights due to differences in realized returns across asset classes. The first hypothesis

[14]We convert TDF stock-level-ownership to country-level-ownership based on the firm's headquarters. In a robustness test, we also classify firms by country based on the incorporation rather than the headquarters. The country-level figures exclude countries that have less than 10 firms per year and countries that do not have stock data for the entire sample period. Thus, our sample includes TDF holdings in 42 countries: Argentina, Australia, Austria, Belgium, Bermuda, Brazil, Canada, Chile, China, Columbia, Czech Republic, Denmark, Finland, France, Germany, Greece, Hong Kong, Hungary, Indonesia, India, Ireland, Israel, Italy, Japan, Korea, Mexico, Malaysia, Netherlands, Norway, New Zealand, Peru, Philippines, Poland, Portugal, Singapore, Spain, Sweden, Switzerland, South Africa, Thailand, Turkey, and the United Kingdom.

stems from the life-cycle portfolio choice theory which argues that TDFs should focus primarily on the allocation to risky versus safe assets (e.g., Viceira, 2001; Cocco, Gomes, and Maenhout, 2005; Campbell, 2016; Dahlquist, Setty, and Vestman, 2018; Parker, Schoar, and Sun, 2023). This implies that TDFs would have target weights for equity versus fixed income, but within the equity part of their portfolio, TDFs implement a flexible asset allocation policy with respect to different equity sub-asset classes. Under this *Inertia Hypothesis*, TDFs will not implement any rebalancing, selling, or other actions to address the changes in weights of domestic relative to foreign equities.

The second hypothesis originates from the observation that even though the split between domestic and foreign equities is not grounded in the life-cycle portfolio choice theory, many TDFs implement separate target allocation weights for the equity sub-asset classes. Thus, TDFs may rebalance their equity portfolio in response to differences in returns between the equity subclasses (Calvet, Campbell, and Sodini, 2009). This *Rebalancing Hypothesis* predicts that TDFs will frequently adjust their portfolio to counterbalance the changes in the actual asset allocation and maintain a portfolio composition closely resembling the target weights. The rebalancing can be implemented by allocating any positive net inflows to the underweighted equity sub-asset class or through sales of the overweighted equity sub-asset class and purchases of the underweighted equity sub-asset class.

The third hypothesis contends that TDFs may not be willing to rebalance their portfolio weights to subclasses of risky assets but could be still concerned that a prolonged deviation from their target policy can be perceived as a violation of their mandate and investment prospectus. If TDFs want to reduce rebalancing costs, they can adjust their target asset allocation weights in the same direction that realized returns move the actual allocation weights. This *Changing Target Hypothesis* predicts that the target asset allocation weights will increase for the equity sub-asset class that has experienced relatively higher returns in the previous period.

3.1 Rebalancing Decisions and Trades

This section examines the rebalancing decisions of TDFs in foreign and domestic equity. We start the analysis by documenting that most TDFs distinguish between foreign and domestic equities in their asset allocation policy and closely follow these target weights in their portfolio decisions. Figure 3 presents the correlation between the aggregate flows of TDFs to the different asset classes and the return differences between the asset classes. Panel A displays the differences in flows and returns between foreign and domestic equities, while Panel B plots the differences in flows and returns between foreign equities and fixed income.

The two subclasses of equity exhibit a strong negative relation between the return difference and rebalancing flow difference. When the foreign equity benchmark outperforms the domestic equity benchmark, TDFs rebalance away from foreign equities to domestic equities. The correlation between the differences in flows and returns between foreign and domestic equities is -0.65, which is almost as high as the correlation between foreign equities and fixed income of -0.88. Overall, this figure suggests that TDFs make a clear distinction between their holdings of domestic and foreign equities and rebalance between these two equity subclasses with a high frequency.

Next, we test our hypotheses more formally. In Table 3, we examine the asset allocation of TDFs to foreign equities and test the *Inertia* and *Rebalancing* hypotheses. The unit of observation is a TDF-quarter and we use two measures of actual TDF rebalancing behavior as dependent variables: rebalancing flow ($RebalFlow_q^{FE}$) and rebalancing weight ($RebalWeight_q^{FE}$). Our main independent variable is the predicted rebalancing flow to foreign equity. This predicted flow is based on Parker, Schoar, and Sun (2023), who focus on a two-asset framework of equity and fixed income. In Online Appendix A.1 we explain in detail how we derive the predicted rebalancing measure for our setting with a three-asset model.

We calculate the predicted rebalancing flow to foreign equities, $PredRebal^{FE}_{k,q}$, as follows:

$$PredRebal^{FE}_{k,q} = \underbrace{-\omega^{FE}_{k,q-1}\omega^{FI}_{k,q-1}(R^{FE}_{Bench,q} - R^{FI}_{Bench,q})}_{PredRebal^{FE-FI}_{k,q}} \underbrace{-\omega^{FE}_{k,q-1}\omega^{DE}_{k,q-1}(R^{FE}_{Bench,q} - R^{DE}_{Bench,q})}_{PredRebal^{FE-DE}_{k,q}}, \quad (8)$$

where $\omega^{FE}_{k,q-1}$, $\omega^{DE}_{k,q-1}$ and $\omega^{FI}_{k,q-1}$ denote TDF k's actual foreign equity, domestic equity and fixed income weights at quarter $q-1$. $R^{DE}_{Bench,q}$, $R^{FE}_{Bench,q}$ and $R^{FI}_{Bench,q}$ are benchmark returns for domestic equity, foreign equity, and fixed income at quarter q.

In Equation (8), we decompose predicted rebalancing flow to foreign equity into two components: the first component, $PredRebal^{FE-FI}_{k,q}$, denotes the rebalancing between foreign equity and fixed income proportionally to foreign equity. The second component, $PredRebal^{FE-DE}_{k,q}$, denotes the rebalancing between foreign and domestic equities. When the aggregate foreign equity return $R^{E}_{Fund,q}$ is lower than the fixed income return $R^{FI}_{Fund,q}$, $PredRebal^{FE-FI}_{k,q}$ has a positive sign, meaning positive inflows into foreign equity in order to keep the weight of foreign equity stable. Likewise, $PredRebal^{FE-DE}_{k,q}$ is positive when $R^{FE}_{Fund,q}$ is lower than $R^{DE}_{Fund,q}$.

Besides the predicted rebalancing flow, we also use two other independent variables: the realized return differences of the benchmark indices and the realized return differences of the TDFs mutual fund holdings. $R^{FE}_{Bench,q} - R^{DE}_{Bench,q}$ captures the difference between the returns on Vanguard Total International Stock Index Fund and CRSP value-weighted U.S equity index as benchmarks for foreign and domestic equity. $R^{FE}_{Bench,q} - R^{FI}_{Bench,q}$ captures the difference between the returns on Vanguard Total International Stock Index Fund and Vanguard Total Bond Market Index Fund as benchmarks for foreign equity and fixed income.

Next, we use the actual returns of the TDF's underlying mutual funds to estimate the differences in returns between the underlying asset classes. $R^{DE}_{Fund,q}$, $R^{FE}_{Fund,q}$, and $R^{FI}_{Fund,q}$ are value-weighted returns of a TDF's underlying domestic equity, foreign equity, and fixed income mutual funds.

In Table 3, we estimate the following specifications to test the TDF rebalancing decisions in response to differences in asset class returns:

$$Y_{k,q}^{FE} = \beta_1 X_{k,q} + \beta_2 X_{k,q-1} + \gamma Z_{k,q} + \delta_k + \varepsilon_{k,q}, \tag{9}$$

where the dependent variable $Y_{k,q}^{FE}$ is either the rebalancing flow ($RebalFlow_q^{FE}$) or the rebalancing weight ($RebalWeight_q^{FE}$). As discussed above, we use three sets of independent variables: 1) predicted rebalancing flows $PredRebal_{k,q}^{FE-DE}$ and $PredRebal_{k,q}^{FE-FI}$, 2) benchmark return differences ($R_{Bench,q}^{FE} - R_{Bench,q}^{DE}$) and ($R_{Bench,q}^{FE} - R_{Bench,q}^{FI}$), and 3) realized return differences of underlying mutual funds ($R_{Fund,q}^{FE} - R_{Fund,q}^{DE}$) and ($R_{Fund,q}^{FE} - R_{Fund,q}^{FI}$). For the independent variables, we use both contemporaneous and lagged quarterly values. The specifications include TDF fixed effects (δ_k) and the following time-varying control variables at the TDF level ($Z_{k,q}$): the logarithm of lagged size of the TDF, the logarithm of lagged size of the TDF series, the cash share in the TDF portfolio, investor net flow to the TDF, TDF quarterly return, and years to retirement.[15]

The *Inertia* hypothesis predicts no significant relation between the rebalancing measures and the differences in returns between the underlying asset classes (i.e., $\hat{\beta}_1 = \hat{\beta}_2 = 0$). On the other hand, the *Rebalancing* hypothesis predicts a positive relation between the rebalancing flow or weight and the predicted rebalancing as well as a negative relation between the rebalancing flow or weight and the return differences between foreign equities and domestic equities. Column (1) of Table 3 provides supportive evidence for the *Rebalancing* hypothesis and against the *Inertia* hypothesis: TDFs rebalance 52.6% of the predicted flow between foreign and domestic equities, as well as 71.8% of the predicted flow between foreign equities and fixed income in the same quarter. Most of the rebalancing occurs contemporaneously in the same quarter as the relation with the lagged predicted

[15]The years-to-retirement is calculated as the current year minus the TDF target year. For TDF income funds, the years-to-retirement is set to be 0.

rebalancing is much weaker and not statistically significant. Column (4) confirms that these results are robust when using the rebalancing weight ($RebalWeight_q^{FE}$) measure as a dependent variable.

We then decompose the return drivers of $PredRebal_q^{FE}$ and show that the return difference between foreign equity and domestic equity has a similar impact on the rebalancing trades in foreign equities as the return difference between foreign equity and fixed income. Based on Column (5), a 5 percentage point difference between the benchmark returns on foreign and domestic equity is associated with a -0.34% ($= 5 \times -0.067$) rebalancing reduction in the weight on foreign equities. To gauge the economic significance, recall from Figure 1 that the aggregate TDF assets under management were around $1.50 trillion in 2022. Hence, a 5 percentage point difference between the quarterly benchmark returns on foreign and domestic equity results in a $5.03 billion outflow from the foreign equity holdings of TDFs in the same quarter. In Columns (3) and (6), we document economically and statistically similar results when focusing on the differences in returns on the underlying mutual funds instead of analyzing the differences in returns on the asset class benchmarks.

In Table 4, we extend the analysis by focusing only on the residual rebalancing flows or weight in foreign equity that can be attributed only to the difference in returns between foreign and domestic equity. This extension addresses potential concerns that the returns on domestic equity and fixed income might be correlated and our previous rebalancing measures would capture rebalancing trades that only correct the equity versus fixed income weights. The dependent variables in Table 4 measure the residual rebalancing flow or weight that is constructed under the assumption that TDFs revert 100% of the mechanical changes in weights between the total equity and fixed income holdings. This assumption is conservative as Parker, Schoar, and Sun (2023) show that TDFs rebalance 60% to 70% the predicted amount between equity and fixed income.

In Column (1), we find that the predicted rebalancing flow to foreign equity from domestic equity is also significantly related to the residual rebalancing flow that can be attributed only to the

difference in returns between foreign and domestic equity. Column (4) confirms that the predicted rebalancing of foreign equity from domestic equity is significantly related to the allocation weights changes between domestic and foreign equity. In this table, the coefficients on the return differences with fixed income are insignificant by design as we removed their impact when constructing the residual rebalancing dependent variables. Based on Column (5), a 5 percentage point difference between the benchmark returns on foreign and domestic equity is associated with a 0.42% (= 5 × 0.083) rebalancing reduction in the weight on foreign equities.

In Online Appendix Tables A.1 and A.2 we examine whether passive and active TDFs implement similar rebalancing decisions in response to the differences in returns between foreign and domestic equities. We classify passive TDFs as having more than 50% of their assets invested in index funds, while active TDFs have the majority of their holdings invested in actively managed funds. We find that both passive and active TDFs rebalance away from foreign equities when foreign equities outperform domestic equities to maintain the actual asset allocation weights close to the target weights. The rebalancing trades of passive TDFs are marginally larger and faster than the rebalancing trades of active TDFs. In terms of the rebalancing flow between domestic and foreign equities, passive TDFs rebalance 63.4% of the predicted flow in the same quarter, while active TDFs rebalance 47.2% of the predicted flow in the same quarter.

In summary, when implementing the life-cycle asset allocation strategy, TDFs treat domestic and foreign equity as separate asset classes and rebalance within the same quarter to maintain stable weights of these two equity categories.

3.2 Changing the Target Asset Allocation

This section tests the *Changing Target Hypothesis* which argues that TDFs will adjust the target asset allocation weights in response to differences in returns between the equity sub-asset classes

rather than rebalancing the portfolio. The analysis is limited to the subsample of TDFs that disclose their target asset allocation in the investment prospectus. We use two dependent variables to capture the TDF's target portfolio allocation: $\omega^{FE}_{target,q}$ is the TDF's target allocation to foreign equity; and $\Delta\omega^{FE}_{target,q}$ is the quarterly change in the target weight to foreign equity.

The *Changing Target Hypothesis* predicts that the changes in target allocation weights will absorb any mechanical changes in the actual weights due to differences in realized returns between domestic and foreign equities. Thus, if the return on foreign equities is higher than the return on domestic equities, TDFs will increase their target allocation to foreign equities. Table 5 presents results that are inconsistent with this hypothesis. Columns (1) to (3) show that the level of target allocation to foreign equities responds neither to the differences in returns between foreign and domestic equity nor to the differences in returns between foreign equity and fixed income. Columns (4) to (6) confirm that the change in target allocation to foreign equities also does not reflect differences in returns between the asset classes in TDFs' portfolios.

Overall, the *Inertia Hypothesis* and *Changing Target Hypothesis* have limited empirical support. Instead, we document that TDFs rebalance their equity portfolio and act as contrarian investors in international stock markets. Following high returns on foreign equities relative to domestic equities, TDFs sell foreign equities and buy domestic equities to rebalance their portfolios back to the target asset allocation within the same quarter.

3.3 Foreign Equity Local Return and Currency Return

The return on foreign equity is determined by two components: the foreign equity return expressed in the local currency and the currency return that depends on the movements of the USD exchange rate relative to the foreign currencies. If TDFs define their desired portfolio composition using the stock market weights expressed in local currency and do not hedge currency risk exposure, TDFs

will need to rebalance their equity portfolio in response to changes in the exchange rate. On the other hand, if TDFs (or their underlying foreign equity mutual funds) hedge currency risk, changes in exchange rates will not trigger TDF rebalancing. This section studies which component(s) of the foreign equity returns drive the rebalancing decisions.

In Table 6, we examine how variation in foreign equity return driven either by the local equity return or by the currency return affects the TDFs' rebalancing flow or weight. As we only have data on the U.S. dollar denominated returns on the foreign equity fund holdings of the TDFs and no information on their currency hedging activity, we first need to estimate to what extent the foreign equity returns are affected by exchange rate changes. To this end, we use a two-stage least squares (2SLS) method. The first stage presents the relation between the TDFs' foreign equity return and the two components. The coefficient on β_1 using the two-stage estimation measures the effect that local equity return or currency return has on the rebalancing trades. We measure the local currency denominated equity returns using the return on the MSCI ACWI ex USA local gross index. The currency return is calculated as the difference between the MSCI ACWI ex USA USD gross index and the MSCI ACWI ex USA local gross index. The second stage is similar to Equation (6).

The first-stage results demonstrate that both local currency denominated equity returns and currency returns significantly influence the return on foreign equity mutual funds held by the TDFs. If the underlying foreign equity mutual funds would hedge currency risk, we would expect that any changes in the exchange rate will not affect the TDF return in foreign equity. However, Column (3) shows that a 1 percentage point return on the USD relative to the local currency results in a 0.94 percentage point return on the TDF's underlying foreign equity mutual funds.

The second-stage results show the relation between the rebalancing trades and the return on foreign equity, considering only variation in the foreign equity return that is driven either by the local equity return or the currency return. We find that TDFs rebalance in response to both foreign equity

local returns as well as currency returns. The coefficients suggest that TDFs respond relatively more to return movements caused by the local equity market than to currency returns. Based on Panel B Column (1), the rebalancing flow responds with an outflow of -0.09% to a 1 percentage point higher foreign equity return when that increase in the return is driven by an increase in the currency return. Based on Column (2), the rebalancing flow responds with an outflow of -0.12% to a 1 percentage point higher foreign equity return when an increase in the local equity return drives that increase in the return. Using the residual rebalancing flow or the rebalancing weight as a dependent variable confirms this interpretation.

We conclude that TDFs rebalance their foreign equity holdings in response to the foreign equity return expressed in the local currency and to the currency return. Foreign equity mutual funds held by the TDFs do not (fully) hedge against exchange rate risk, and the TDFs also do not (fully) hedge against exchange rate movements at the aggregate portfolio level.

4 Impact on Foreign Equity Mutual Fund Flows

So far, we have shown that TDFs often have explicit target weights for foreign equity and they adopt contrarian rebalancing strategies to maintain a relatively stable allocation to foreign equity. Next, we study potential consequences of this rebalancing behavior. First, this section examines the implications for the flow-performance sensitivity of foreign equity mutual funds.

On average, mutual fund investors display a significant positive flow-performance sensitivity and direct disproportionally more flows to the best-performing mutual funds. The performance-chasing by mutual fund investors has been documented for U.S. domestic mutual funds (e.g., Sirri and Tufano, 1998; Frazzini and Lamont, 2008) as well as for U.S. foreign equity mutual funds (e.g., Froot, O'Connell, and Seasholes, 2001; Jotikasthira, Lundblad, and Ramadorai, 2012).

However, TDFs display a contrarian trading behavior based on their rebalancing activity. We

hypothesize that foreign equity mutual funds with a higher TDF ownership will display a weaker positive flow-performance sensitivity or even a negative one, compared to funds with low or no TDF ownership. Since TDFs' asset allocation between foreign and domestic equity and fixed income depends on relative (not absolute) performance, we expect that foreign equity mutual funds will receive redemption requests when foreign equity outperforms the other asset classes in the TDF portfolio. By 2022, TDFs have increased their ownership share to 10% of all assets owned by U.S. foreign equity mutual funds. The growing ownership share of TDFs may weaken the aggregate positive flow-performance sensitivity of the foreign equity mutual funds industry.

To examine the relation between TDF ownership and foreign equity mutual fund flow-performance sensitivity, we use a sample that includes all U.S. foreign equity mutual funds reporting in the CRSP Mutual Fund dataset. We estimate the flows to foreign equity mutual fund i at quarter q as:

$$MFflow_{i,q} = \frac{TNA_{i,q} - TNA_{i,q-1}(1 + R_{i,q})}{TNA_{i,q-1}}, \tag{10}$$

where $TNA_{i,q}$ is the total net assets of fund i at quarter q, and $R_{i,q}$ is the quarterly return of fund i.

Next, we estimate the following panel regression specification to measure the flow-performance sensitivity to return differences that influence the rebalancing decisions of TDFs:

$$MFflow_{i,q} = \beta_1 X_{i,q} + \beta_2 X_{i,q-1} + \beta_3 \left(X_{i,q} \times \%TDF_{i,q-1}\right) + \beta_4 \left(X_{i,q-1} \times \%TDF_{i,q-1}\right) + \gamma Z_{i,q} + \delta_i + \varepsilon_{i,q}, \tag{11}$$

where $X_{i,q}$ captures the contemporaneous and lagged quarterly differences in benchmark returns between foreign equity and other asset classes ($R^{FE}_{Bench,q} - R^{DE}_{Bench,q}$), or ($R^{FE}_{Bench,q} - R^{FI}_{Bench,q}$). In Columns (5) and (6), instead of benchmark returns, we directly use the foreign equity mutual fund return ($R_{i,q}$) and control for quarterly fixed effects. The specifications include mutual fund fixed effects (δ_k) and the following time-varying control variables at a mutual fund level ($Z_{i,q}$): the lagged

log mutual fund size, lagged log mutual fund family size, current log mutual fund age, current cash allocation share, and current expense ratio. The control variables also include the $\%TDF_{i,q-1}$ which measures the TDF ownership of mutual fund i in quarter $q-1$. We interact this variable with the return differences to examine the effect of TDF ownership on the flow-performance sensitivity.

Column (1) of Table 7 shows that the flows to the foreign equity mutual fund on average are only marginally positively related to the lagged difference in benchmark returns between foreign equity and domestic equity. If foreign equities outperform domestic equities by 5 percentage points, foreign equity mutual funds will receive positive inflows of approximately 0.89% ($= 5 \times 0.178$) of their lagged TNAs. The baseline effect of TDF ownership on mutual fund flows is positive as TDFs have experienced substantial growth in assets under management since they were designated as a default retirement product. However, Column (2) shows that foreign equity mutual funds with a high TDF ownership actually face outflows when foreign equities outperform domestic equities. For instance, when foreign equities outperform domestic equities by 5 percentage points, a mutual fund that is completely owned by TDFs will experience -2.53% ($= 5 \times 1 \times -0.506$) outflows of their lagged TNAs in the same quarter relative to a mutual fund that has a 0% TDF ownership. This negative coefficient estimate on the interaction term outweighs the positive baseline coefficient estimate on flow-performance sensitivity of 0.151. The overall outflows from foreign equity mutual funds with a high TDF ownership are larger as the relation with the lagged difference in benchmark returns between foreign equity and domestic equity displays a similar economic and statistical significance.

Columns (3) and (4), focus on the difference in benchmark returns between foreign equity and fixed income, instead of domestic equity. Foreign equity mutual funds on average receive substantial positive inflows when foreign equity outperforms fixed income. This positive sensitivity of flows to relative performance is also persistent as it is significant in the contemporaneous as well as the lagged quarter. However, this test also shows that foreign equity mutual funds with a high TDF

ownership differ from the other mutual funds and face redemption requests when foreign equity outperforms fixed income. Again, the negative coefficients on the interaction terms in Column (4) outweigh the positive baseline coefficients on flow-performance sensitivity.

In Columns (5) and (6), we focus directly on the returns of the underlying mutual funds. The advantage of this setting is that we can measure more precisely the returns experienced by the mutual fund investors and TDFs and include quarterly fixed effects. The disadvantage is that we do not have a clear benchmark to measure relative performance which is the main driver of TDF rebalancing decisions in foreign equity. We confirm the results of prior mutual fund literature on the strong return-chasing behavior of mutual fund investors. Based on Column (6), if a mutual fund has a 10 percentage points higher absolute return, it will receive 3.06% inflows. However, here as well the interaction term with TDF ownership is significant and negative and outweighs the baseline evidence on return-chasing behavior. Foreign equity mutual funds with a high TDF ownership do not receive positive inflows and even tend to face outflows in case of high absolute performance.

The specifications in Table 7 use the entire sample of $2,506$ U.S. foreign equity mutual funds. One potential concern is that most of these mutual funds are smaller and not owned by TDFs. As a robustness test in Online Appendix Table A.3, we limit attention to the subsample of 386 mutual funds that have ever been owned by a TDF during the 2011–2022 period. In this subsample, the interaction terms between the return differences and the percentage of TDF ownership have similar economic and statistical significance.

Overall, our results suggest that TDFs sell foreign equity mutual funds when the foreign equity outperforms other asset classes, and buy more shares of these funds when the foreign equity underperforms. These rebalancing inflows and outflows from the TDFs to their underlying mutual funds can influence the comovement of the foreign stocks owned by these mutual funds, which is what we test in the next section.

5 Impact on Foreign Stock Return Comovements

Through their foreign equity mutual funds, TDFs own a substantial portion of foreign equities. Prior research shows that foreign equity mutual funds can influence the prices of foreign equity through their asset sales and purchases induced by performance-chasing flows (Jotikasthira, Lundblad, and Ramadorai, 2012). We find that mutual funds that are owned by TDFs actually face contrarian flows. Therefore, we hypothesize that mutual funds with high TDF ownership will have a distinct impact on the underlying stocks. Their flows depend primarily on the difference in returns between foreign equity and domestic equity so their foreign equity holdings will also load significantly on this return difference. Our main hypothesis is that foreign stocks with a higher TDF ownership will have a positive exposure to the difference in returns between domestic equity and foreign equity. These stocks will co-move more with the U.S. stock market and TDFs' rebalancing decision will transmit shocks from the U.S. equity market to the international stock markets.[16]

To test this conjecture, we use data on all foreign stocks that have ever been owned by TDFs. In the first step, we estimate the exposure of foreign stock s to the difference in benchmark returns between foreign equities and other asset classes in the TDF portfolio:

$$R^{USD}_{s,m} = a_{s,m} + b_{s,m} X_m + \epsilon_{s,m}, \tag{12}$$

where $R^{USD}_{s,m}$ is the monthly return (USD) of foreign stock s at month m, and the regressor X_m is the monthly benchmark return difference, either between foreign equity and domestic equity ($R^{FE}_{Bench,m} - R^{DE}_{Bench,m}$) or between foreign equity and fixed income ($R^{FE}_{Bench,m} - R^{FI}_{Bench,m}$). In alternative specifications, we also add the lagged return difference ($R^{FE}_{Bench,m-1} - R^{DE}_{Bench,m-1}$) or

[16] Even though the TDF ownership is relatively small and accounts on average for 0.57% of foreign countries' market capitalization during our sample period, their trading decisions can be seen as a proxy for a broader set of investors (e.g., collective investment trusts, balanced funds, pension funds) that frequently rebalance their portfolio in similar ways in order to maintain a steady asset allocation to foreign and domestic equity.

$(R^{FE}_{Bench,m-1} - R^{FI}_{Bench,m-1})$. In all these specifications, we use a rolling window of 36 months and obtain a panel of $\hat{b}$ estimates on the stock-month level. We exclude stocks that have less than 24 observations within the rolling window.

In the second step, we match the stock-level $\hat{b}$ estimates at the end of every quarter with data on TDF ownership and other firm characteristics.[17] Using these stock-level $\hat{b}$ as a dependent variable, we estimate the following specification:

$$\hat{b}_{s,q} = \alpha + \beta_1 \%TDF_{s,q-1} + \beta_2 \%OMF_{s,q-1} + \gamma_1 Z_{s,q} + \gamma_2 M_{c,q} + \gamma_3 M_q + \delta_s + \varepsilon_{s,q}, \tag{13}$$

where $\%TDF_{s,q-1}$ is the TDF ownership of stock s at lagged quarter $q-1$. $\%OMF_{s,q-1}$ is the lagged ownership of stock s by other (non-TDF) U.S. foreign equity mutual funds, which enables us to isolate the effect of TDF ownership from other mutual fund investors. We estimate $\%OMF_{s,q-1}$ as the difference between the total ownership stake of U.S. foreign equity mutual funds and the ownership stake of TDFs of stock s in quarter $q-1$.

The specifications include the following $Z_{s,q}$ stock-level control variables: the one-quarter lagged stock return, log of lagged values of market capitalization, turnover, market-to-book ratio, and lagged values of dividend yield, ROE, investment, and illiquidity. We also control for $M_{c,q}$ county and currency-level characteristics. Country-level control variables include lagged stock market capitalization, GDP, CPI, interest rate, developed country indicator, local market stock return, and local stock market volatility. Currency-level control variables include the lagged one-quarter to four-quarter exchange rate change and exchange rate volatility. The specifications also include time-varying controls M_q for the lagged ACWI ex-US index quarterly return and volatility. The specifications include stock fixed effects δ_s. We triple-cluster the standard errors by stock, country, and quarter, and report standard errors in brackets.

[17] Essentially, we use only betas estimated for months 3, 6, 9, and 12 in the analysis, and exclude all the other betas.

In these specifications, we examine a variation of the beta within the same firm. The TDF ownership stake varies within a firm as well as in the cross-section of firms for two reasons. First, the majority of underlying mutual funds receiving capital from TDFs are actively managed so they can adjust their positions across firms. Second, even passively managed mutual funds also need to adjust their position in response to index changes and may use different indexes as benchmarks.

Table 8 presents the results of the second-step regressions using the estimated stock return exposures as dependent variables. A higher coefficient on $\hat{b}_{s,q}^{FE-DE}$ indicates that stock s correlates more with the returns on foreign equities and less with the returns on U.S. equities. A lower coefficient on the dependent variable $\hat{b}_{s,q}^{FE-DE}$ indicated that stock s co-moves more together with the U.S. equity market. Based on our hypothesis, we would expect a stock with higher TDF ownership to have lower or even negative $\hat{b}$.

We find that foreign stocks with a higher TDF ownership display are relatively more exposed to the U.S. equity market. Based on Column (1), if a stock experiences a 1 percentage point increase in the TDF ownership the beta on the difference in returns between foreign equity and domestic equity will decrease by around 3.4 basis points. This lower beta implies that when the TDF ownership of a foreign stock increases, the return of this stock moves in the opposite direction with the return difference between foreign equity and domestic equity benchmark. In Columns (3) and (4), we observe that TDF ownership has a smaller insignificant effect on the stock beta with respect to the difference in benchmark returns between foreign equity and fixed income.

This effect of TDF ownership on stock-level betas cannot be explained by the overall foreign equity mutual fund ownership. The ownership by other mutual fund investors $OMF_{s,q-1}$ is not significantly related to stock-level exposures to the return difference between foreign equity and domestic equity benchmarks. Thus, TDF rebalancing flows between foreign and domestic equity seem to have a distinct relation to the co-movement of international stock markets.

In Table 8, we use all 5,322 foreign stocks that have ever been owned by TDFs from 2011Q1 to 2022Q4. This sample is broad but it excludes (smaller) companies that have never been owned by TDFs. In a robustness test, we extend our baseline sample to 5,581 foreign stocks that have ever been owned by any U.S. foreign equity mutual fund. Online Appendix Table A.4 shows that our results are robust to this sample expansion. The economic and statistical significance of the effect of TDF ownership on stock-level betas remains the same.

In sum, we provide evidence that TDF rebalancing trades are related to the comovement of foreign stocks even though TDFs do not directly invest in stocks. The returns of foreign stocks with a higher TDF ownership tend to move more in the direction of U.S. equity returns and move less in the direction of foreign equity returns.

6 Impact on Exchange Rates

In this section, we explore the implications of TDFs' contrarian rebalancing activity for exchange rates. Specifically, we study the relation between their rebalancing flows and the exchange rates of foreign countries that are affected by these flows. Various studies document that capital flows from foreign equity mutual funds and other institutional investors can influence exchange rates (e.g., Hau, Massa, and Peress, 2010; Camanho, Hau, and Rey, 2022; Aldunate, Da, Larrain, and Sialm, 2023). Analyzing TDFs separately can lead to new insights, because TDFs engage in contrarian rebalancing. In other words, when the U.S. stock market delivers relatively higher returns or when the U.S. dollar appreciates, TDFs will respond by purchasing foreign equities. We hypothesize that these resulting inflows from the TDFs may lead to an appreciation of the foreign currency. The effect should be stronger in countries and currencies with relatively higher TDF ownership. This forms the basis of our tests.

To study the impact on exchange rates, we convert the stock-level data to currency-level or

country-level data. Our stock-quarter panel includes stocks from 88 different countries, and our final currency-quarter panel includes 67 currencies from 2011Q1 to 2022Q4. Figure 4 shows the percentage of TDF foreign equity holdings invested in the ten main foreign currencies. These 10 main currencies are defined at the end of our sample period, but the allocation is relatively stable over time.[18] Across the foreign currencies, we observe an increasing trend in the holdings denominated in CNY and CAD and a decreasing trend in GBP and Other currencies. In this figure, a firm is assigned to one country based on the headquarters location. Online Appendix Figure A.6 assigns firms based on their incorporation country or main trading currency, and shows very similar currency allocation weights.

6.1 Aggregate TDF Rebalancing Flows

In Tables 9 and A.5, the dependent variable $\Delta FX_{s,q}$ measures the change of the exchange rate expressed as foreign currency value per US dollar. A positive value means that the USD has appreciated, while a negative value of this variable means that the foreign currency has appreciated relative to the USD.[19]

$$\Delta FX_{c,q} = \frac{FX_{c,q} - FX_{c,q-1}}{FX_{c,q-1}}. \tag{14}$$

Our main independent variables are based on the aggregate quarterly rebalancing flow of all TDFs to a country or currency c:

$$RebFlow_{c,q} = \sum_{k=1}^{N_{q-1}^{TDF}} \sum_{i=1}^{N_{k,q-1}^{FE}} RebFlow_{k,q}^{FE} \times \omega_{i,k,q-1}^{FE} \times \omega_{i,c,q-1}, \tag{15}$$

[18] In the analysis, we exclude all USD stock holdings as we measure the currency movements relative to the USD. Online Appendix Figure A.6 shows that the holdings of foreign equity mutual funds in U.S. stocks represent 5% to 10% of their portfolio. The investments in USD-denominated stocks by U.S. foreign equity mutual funds can be explained by international diversification strategies implemented by some mutual funds that allocate capital to large U.S.-based multinational companies (Bae, Elkamhi, and Simutin, 2019; Demirci, Ferreira, Matos, and Sialm, 2022).

[19] We use currency data from Eikon Datastream in our analysis.

with $\omega_{i,c,q-1} = \sum_{s=1}^{N^c_{i,q-1}} \omega^c_{i,s,q-1}$. In this measurement, $\omega^c_{i,s,q-1}$ is the share of a stock located in country or currency c owned by mutual fund i in quarter $q-1$. $N^c_{i,q-1}$ is the number of stocks from country or currency c owned by mutual fund i in quarter $q-1$. $\omega^{FE}_{i,k,q-1}$ indicates the share of foreign equity mutual fund i owned by TDF k at quarter $q-1$.

To investigate the impact of rebalancing flow influence, we estimate the following panel regression specifications:

$$\Delta FX_{c,q} = \beta X_{c,q-1} + \gamma_1 Z_{c,q} + \delta_c + \varepsilon_{c,q}. \tag{16}$$

In the analysis, we use three different $X_{c,q-1}$ as our independent variables. First, $RebFlow_{c,q-1}$ is the aggregate amount of rebalancing flows of all TDFs in $ billion. Second, we scale the $RebFlow_{c,q-1}$ with the total market capitalization of currency or country c. Third, we scale the $RebFlow_{c,q-1}$ with the total foreign equity holdings of TDFs in currency or country c. $\hat{\beta}$ measures the sensitivity of the change in the exchange rate to the lagged TDF rebalancing flows. We also create three additional independent variables using the residual rebalancing flow in foreign equities that can be attributed only to the difference in returns between foreign and domestic equity rather than the total rebalancing flow in foreign equities. The specifications include $Z_{c,q}$ controls on a country and currency level as well as currency or country fixed effects δ_c.[20]

If TDF flows are important at an aggregate level, the inflow into foreign markets will generate an appreciation of the foreign currency relative to the U.S. dollar and the coefficient on $\hat{\beta}$ will be negative. This negative coefficient would imply that the local foreign currency appreciates in response to the rebalancing inflows from the TDFs. Tables 9 and A.5 show that all three flow variables are indeed negatively related to the currency returns.

Based on Column (1) of Table 9, a one-standard-deviation increase in the aggregate TDF rebalancing flow, which corresponds to an inflow of $0.17 billion in a given currency in the previous

[20]The inclusion of the control variables reduces our sample to 41 countries and 35 currencies.

quarter, is associated with a 0.28% ($= 0.17 \times -1.637$) appreciation of the foreign currency relative to the U.S. dollar in the following quarter. This effect is robust to controlling for the level of TDF ownership and the ownership of all other foreign equity mutual fund investors.

In Column (3), we scale the rebalancing flows by the foreign equity market capitalization. We find that a 0.1% positive TDF rebalancing flow relative to the market capitalization results in a 3.8% appreciation of the foreign currency. This elasticity is relatively low, but a 0.1% quarterly inflow from TDFs relative to the market capitalization is a very rare outcome that has occurred only a few times in our sample period. Relatively less liquid currencies drive this low elasticity. In Table A.5, we estimate the analysis on a country instead of currency level, which expands the sample of developed countries that use the euro as a common currency. In this specification, a 0.1% positive TDF rebalancing flow relative to the market capitalization results in a 1.5% appreciation of the foreign currency.

One potential concern in international equity markets is that the total market capitalization does not reflect the investable universe if some firms have large (government) blockholders. In Columns (5) and (6) of Table A.5, we scale the TDF rebalancing flows with the total equity holdings owned by the TDFs. Column (5) shows that a 1% positive TDF rebalancing flow relative to the TDF holdings results in a 5.5% appreciation of the foreign currency.

In Figure 5, we present the coefficients of Equation (14) when estimating it separately for the main currencies or regions (we group in geographical regions the smaller currencies in TDF portfolios). The main regressor $RebFlow_{c,q-1}$ is standardized by its standard deviation. All coefficients are negative suggesting that our results are not driven by a subset of the currencies. In both developed and emerging markets, TDF rebalancing inflows result in appreciation of the local currency in the following quarter. Alternatively, the inverse of the coefficient estimates can also be referred to as the price/demand elasticity of the local currency. According to the inelastic market hypothesis by

Gabaix and Koijen (2022), a market with a price elasticity lower than one is regarded as an inelastic market, meaning that a one-dollar capital inflow could increase the aggregate market value by more than one dollar. In Figure 5, we can see that the most elastic currencies are HKD, CAD, and EUR, while the most inelastic currencies are GBP, ZAR, and currencies in Latin America.

In order to put the coefficient estimates across currencies into perspective, the horizontal axis shows the TDF ownership as a percentage of market capitalization at the end of 2021, but the distribution is stable over time.

Our currency elasticity estimations are consistent with Camanho, Hau, and Rey (2022) results on the impact of quarterly rebalancing flows of global mutual funds on currencies in four areas (U.S., U.K., Eurozone, and Canada). Camanho, Hau, and Rey (2022) obtain an implied elasticity estimate of 1.08, while we find that the elasticity of GBP, EUR, and CAD is 0.63, 2.72, and 3.00. Our estimated elasticity in Latin America is 0.64, which is comparable to Aldunate, Da, Larrain, and Sialm (2023) finding of 0.81 price elasticity for the Chilean peso.

6.2 Granular Instrumental Variables

In this section, we use the granular instrumental variables (GIV) approach developed by Gabaix and Koijen (2020) to estimate the overall impact of TDF rebalancing trades on foreign exchange rates and quantify the price elasticity. The GIV approach enables us to estimate the aggregate effects of TDF rebalancing flows more precisely as regressing currency returns against the overall volume of TDF flows is potentially subject to confounding effects from comoving macroeconomic variables. The GIV is constructed by extrapolating idiosyncratic shocks from each TDF and aggregating them using size as a weight. These idiosyncratic shocks can be regarded as exogenous demand shocks to the exchange rate markets.

We follow Camanho, Hau, and Rey (2022) and construct two granular instrumental variables.

The first variable (GIV1) is based on the intuition of netting the idiosyncratic variation driven by fund size. We construct our GIV1 by taking the difference between the value-weighted rebalancing flow and the equal-weighted rebalancing flow at the country or currency level. If the rebalancing flows of small funds and large funds are not significantly different, the value-weighted rebalancing flow should be equal to the equal-weighted rebalancing flow. However, if there is a substantial idiosyncratic variation due to fund size, the difference between value-weighted and equal-weighted rebalancing flow can capture such idiosyncratic variation.

Firstly, we standardized a TDF's aggregate rebalancing flow to each country by the TDF's TNA:

$$\frac{RebFlow_{c,k,q}}{TNA_{k,q-1}} = \sum_{i=1}^{N_{k,q}^{FE}} \frac{RebFlow_{k,q}^{FE}}{TNA_{k,q-1}} \times \omega_{i,k,q-1}^{FE} \times \omega_{i,c,q-1}. \tag{17}$$

Next, GIV1 is constructed as the difference between value-weighted rebalancing flow and equal-weighted rebalancing flow:

$$GIV1_{c,q} = \frac{1}{MV_{c,q-1}^{TDF}} \sum_{k=1}^{N_{q-1}^{TDF}} \frac{RebFlow_{c,k,q}}{TNA_{k,q-1}} \times MV_{k,c,q-1} - \frac{1}{N_{q-1}^{TDF}} \sum_{k=1}^{N_{q-1}^{TDF}} \frac{RebFlow_{c,k,q}}{TNA_{k,q-1}}, \tag{18}$$

where $MV_{k,c,q-1}$ is the market value owned by TDF q in country or currency c at quarter $q-1$, and $MV_{c,q-1}^{TDF}$ is the total market value owned by all TDFs in country or currency c at quarter $q-1$.

Based on Camanho, Hau, and Rey (2022), the second variable (GIV2) is constructed using the residuals ($\varepsilon_{k,q}$) of the following regression that removes the predictable components of the rebalancing flows:

$$\frac{RebFlow_{k,q}}{TNA_{k,q-1}} = \beta Z_{k,q} + \delta_k + \varepsilon_{k,q}, \tag{19}$$

where δ_k is the TDF fixed effect. $Z_{k,q}$ contains TDF level control variables: the logarithm of lagged size of the TDF, the logarithm of lagged size of the TDF series, the cash share in the TDF

portfolio, investor net flow to the TDF, TDF quarterly return, and years to retirement, as well as the interaction terms between these variables and contemperaneous underlying fund return differences $(R^{FE}_{Fund,q} - R^{DE}_{Fund,q})$ and $(R^{FE}_{Fund,q} - R^{FI}_{Fund,q})$. Alternatively, we also include both $(R^{FE}_{Fund,q} - R^{DE}_{Fund,q})$ and $(R^{FE}_{Fund,q} - R^{FI}_{Fund,q})$ as control variables.

Finally, GIV2 is constructed as follows:

$$GIV2_{c,q} = \frac{1}{MV^{TDF}_{c,q-1}} \sum_{k=1}^{N^{TDF}_{q-1}} \sum_{i=1}^{N^{FE}_{k,q-1}} \varepsilon_{k,q} \times \omega^{FE}_{i,k,q-1} \times \omega_{i,c,q-1} \times MV_{k,c,q-1}. \tag{20}$$

Using the above methods, we construct two GIVs. Alternatively, we obtain another two GIVs by replacing $RebFlow$ with $ResidRebFlow^{FE-DE}$. The results of these 2sls regressions are shown in Table 10. Panel A reports the first stage regressions that regress the independent variables (i.e., $RebFlow_{c,q}$ and $ResidRebalFlow^{FE-DE}_{c,q}$) on these two GIVs. The results indicate that these are strong instrument variables as the coefficients are statistically significant and the F-values for four different specifications are all above 10.

In the second stage results in Panel B, the magnitude and significance of the estimated coefficients in Columns (1) and (2) is lower compared to the coefficient in Table 9 (-1.637). However, the coefficients in Columns (3) and (4) are still statistically significant and the magnitude (-4.685 and -3.139) remains similar as compared to Columns (2) in Table 9 (-3.376). This suggests that the exchange rate change is mostly influenced by exogenous demand caused by the return difference between foreign and domestic equity. In sum, the results remain robust and our conclusion is unchanged after applying the granular instrumental variable (GIV) methodology. The estimated elasticity of TDF rebalancing flows driven by the return difference between foreign and domestic equity ranges from 0.21 (1/4.685) to 0.32 (1/3.139).

Overall, we show that TDF rebalancing flows represent relatively large aggregate shocks that

can influence the foreign exchange rates. TDFs provide contrarian flows in international capital markets as they rebalance their holdings towards equity markets that have declined in value or foreign currencies that have depreciated relative to the USD. These flows can stabilize financial markets, but they can also transmit shocks from the U.S. economy to other countries.

7 Conclusion

TDFs are investment products that adjust the allocation between equity and fixed income assets based on the age of their investors. Although standard life-cycle portfolio models do not differentiate between various subcategories of equity, we document that most TDFs implement a target asset allocation policy with rigid target weights for domestic and international equities. We document that TDFs rebalance their subcategories of equity holdings within the same quarter to offset 61% of the mechanical changes in the actual allocation due to differences in realized returns between domestic and foreign equity. Their contrarian rebalancing trades respond to foreign equity local returns and to currency returns, which suggests that TDFs do not (fully) hedge their exposure to exchange rate risk.

TDFs operate as funds-of-mutual-funds and their holdings of U.S. foreign equity mutual funds account for 10% of the total assets managed by these funds in 2022. Through their mutual fund holdings, TDFs have become major owners of foreign equities. We show that their contrarian rebalancing trades have implications for foreign stocks and currencies. Contrary to the prevalent positive flow-performance sensitivity among mutual fund investors, foreign equity mutual funds managing TDF assets experience negative flow-relative-performance sensitivity. When foreign equity outperforms domestic equity, foreign equity mutual funds with a higher TDF ownership face significant outflows.

These TDF mutual fund flows that depend on the relative returns of foreign and domestic equity

are passed on to the underlying holdings and affect also the comovement of stocks and the risk-return characteristics of currencies owned indirectly by the TDFs. The betas of foreign stocks with higher TDF ownership change and the returns of these stocks co-move more with the return on the U.S. domestic equity market and less with the return on the foreign equity market. At an aggregate level, we find that when the U.S. stock market delivers higher returns, TDFs respond by purchasing foreign equities and these rebalancing flows lead to an appreciation of the local currency in countries that attract more capital from TDFs.

Overall, the adoption of TDFs as a default investment product among U.S. defined contribution (401k) pension plans has profound effects on international capital flows. As TDFs have grown in terms of assets under management, foreign equity markets and currencies with higher TDF ownership stakes have benefited from TDFs' relatively more stabilizing contrarian rebalancing flows. However, these countries have also become more exposed to U.S. market movements and foreign exchange policy.

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Figure 1: TDF Asset Allocation

Panel A presents the total assets under management of TDFs from 2011Q1 to 2022Q4 in $ trillion. We split the TDFs into three categories: TDFs that distinguish between domestic and foreign equity and have explicit target allocation weights to foreign equity, TDFs without explicit target weights to foreign equity, and TDFs that do not disclose their target asset allocation (glide path) in the fund prospectuses. Panels B and C focus on the subsample of 80% of TDFs that distinguish between domestic and foreign equity in their asset allocation. Panel B displays the target allocation weights, while Panel C displays the actual allocation weights over time. We classify the TDF assets into three asset classes: foreign equity, domestic equity, and fixed income.

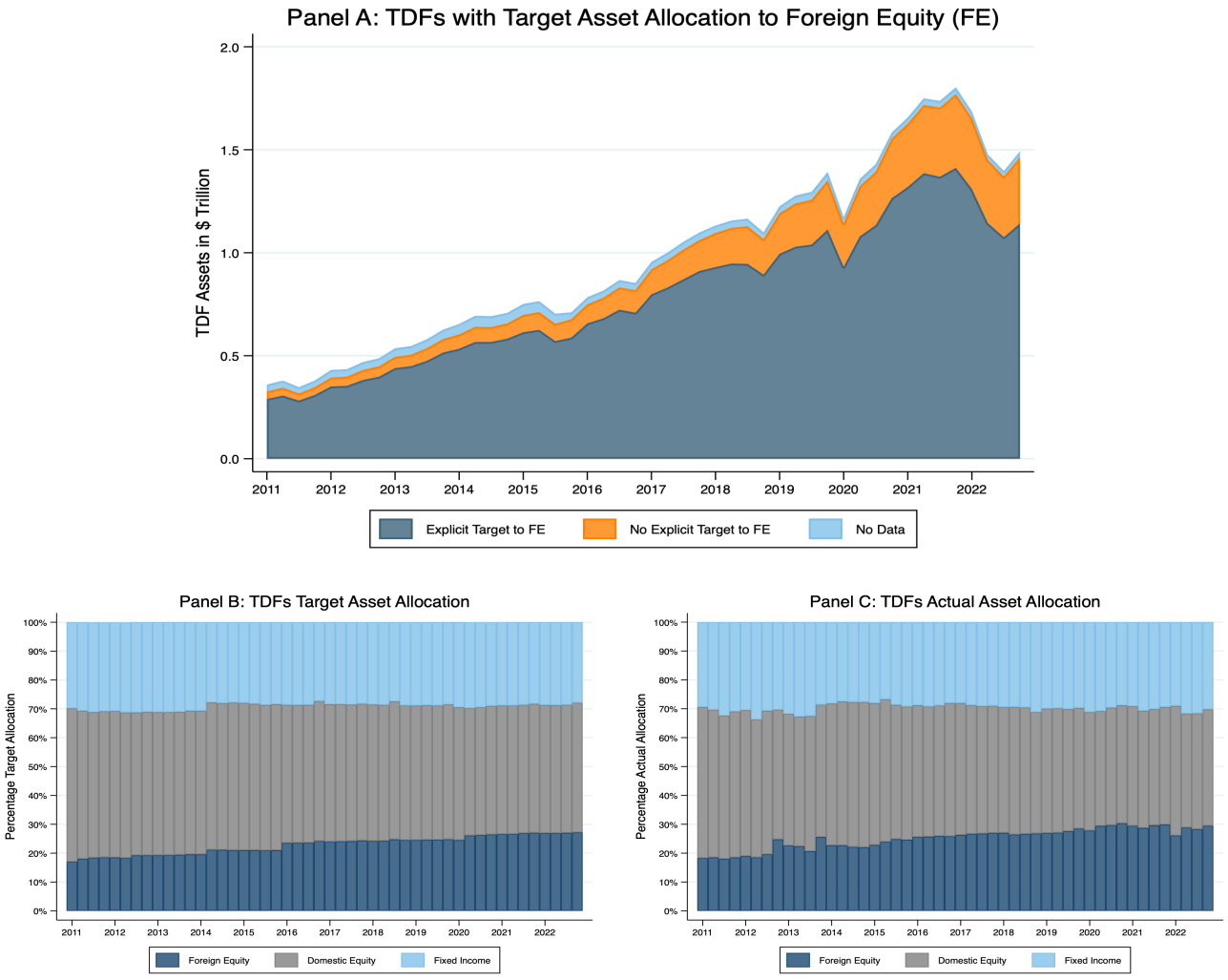


Figure 2: TDF Ownership over Time

These box graphs present the dispersion and ranges of TDF ownership from 2011 to 2022. For each stock, we calculate its total market value, the market value owned by TDFs, and the market value owned by all U.S. foreign equity mutual funds. We allocate each stock to one country based on the firm's headquarters. Panels A and B present TDF ownership as a percentage of the total market capitalization of each stock or country. In Panel C and Panel D, we present TDF ownership as a percentage of the total market value owned by U.S. foreign equity mutual funds. Panel C is on a stock level, while Panel D is on a country level. The lower and upper bounds of the box indicate $p25$ and $p75$. Outliers that are higher than $p25 + 3/2(p75 - p25)$ or lower than $p25 - 3/2(p75 - p25)$ are dropped.

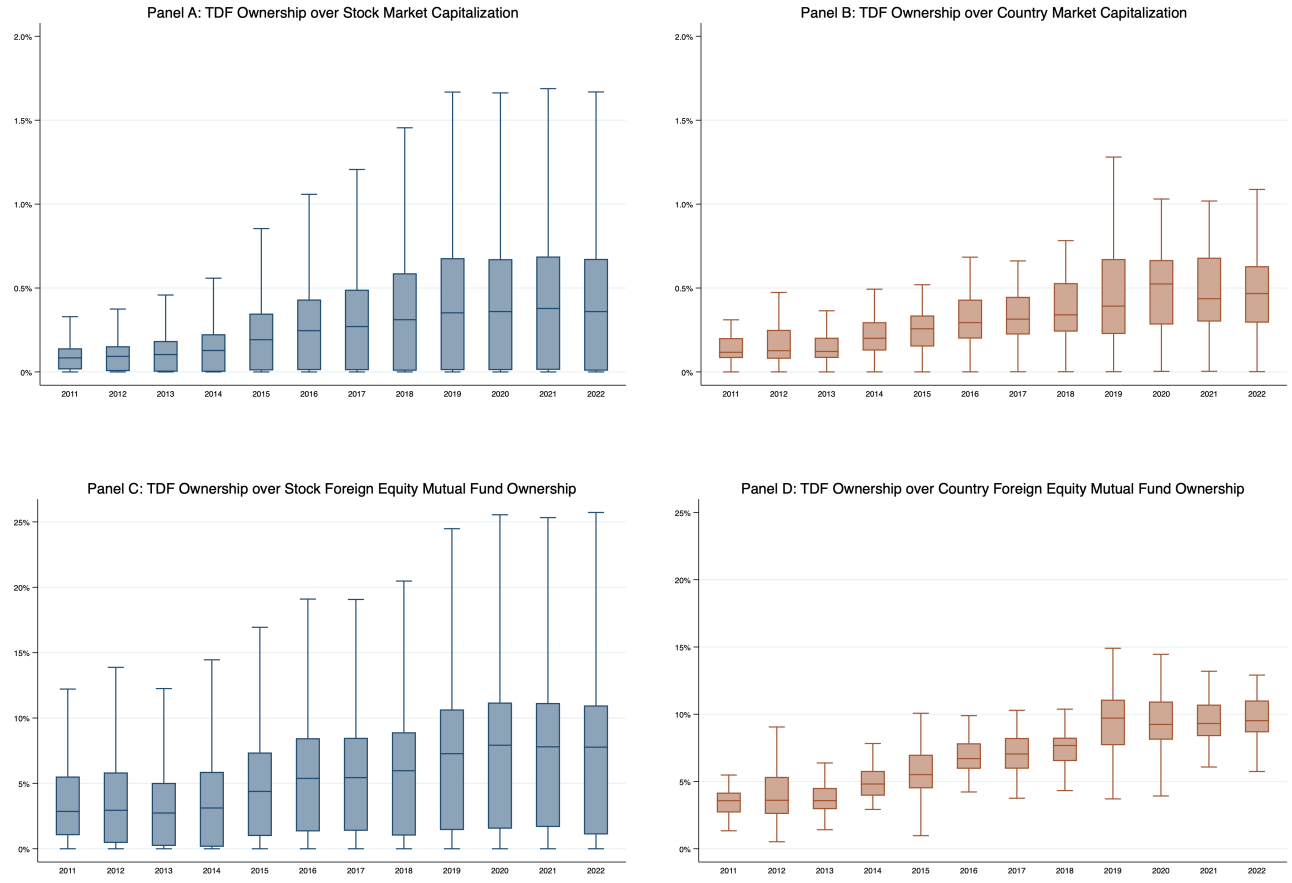
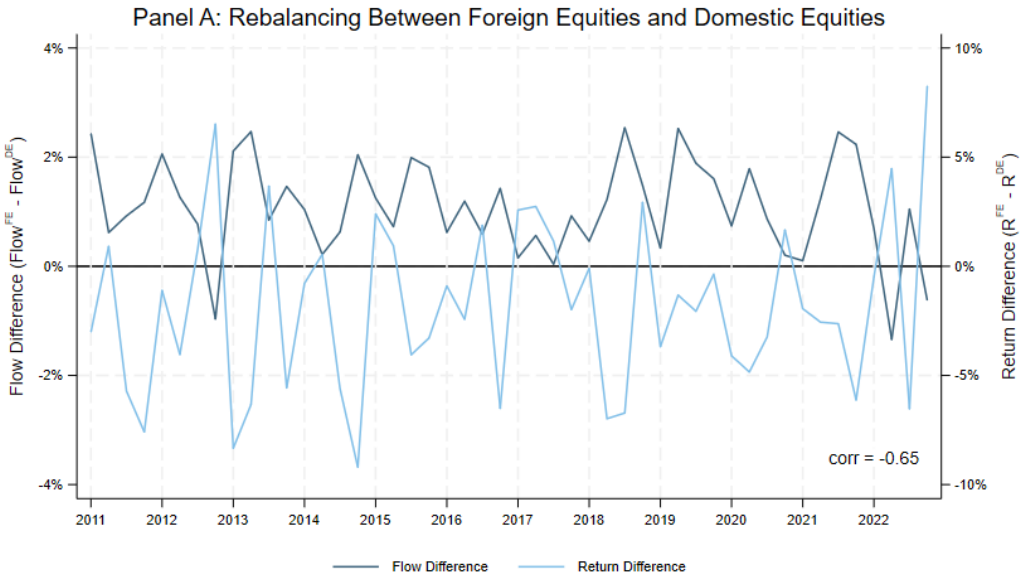


Figure 3: TDF Rebalancing Flows and Return Differences

This figure presents the aggregate flows of TDFs and the return differences between the underlying asset classes. The flow difference captures the difference in aggregate flows of all TDFs between asset classes, scaled by the lagged aggregate assets under management of all TDFs. The return differences are measured using the returns on Vanguard Total International Stock Index Fund, value-weighted U.S. equity, and Vanguard Total Bond Market Index Fund as benchmarks for the performance of foreign equity, domestic equity, and fixed income, respectively. Panel A presents the flow and return differences between foreign equities and domestic equities, while Panel B displays the flow and return differences between foreign equities and fixed income.



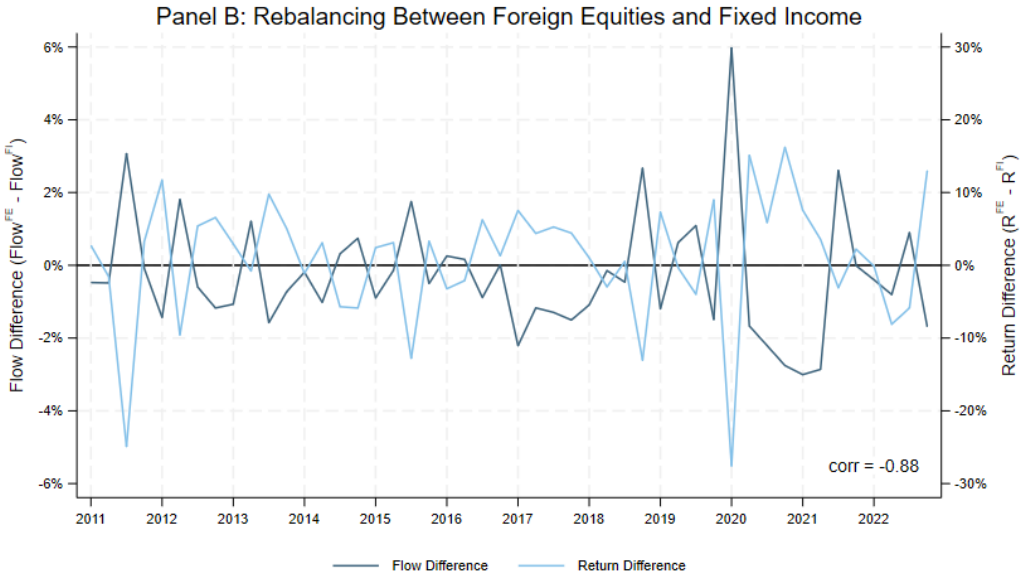


Figure 4: TDF Ownership of Foreign Equities by Currency

This figure splits the aggregate TDF foreign equity holdings by currency. We present the percentage allocation to the 10 main currencies separately and combine all the others. The 10 main currencies are defined at the end of 2022Q4 but their allocation share is relatively constant over time. We classify each stock into one currency based on the location of the firm's headquarters.

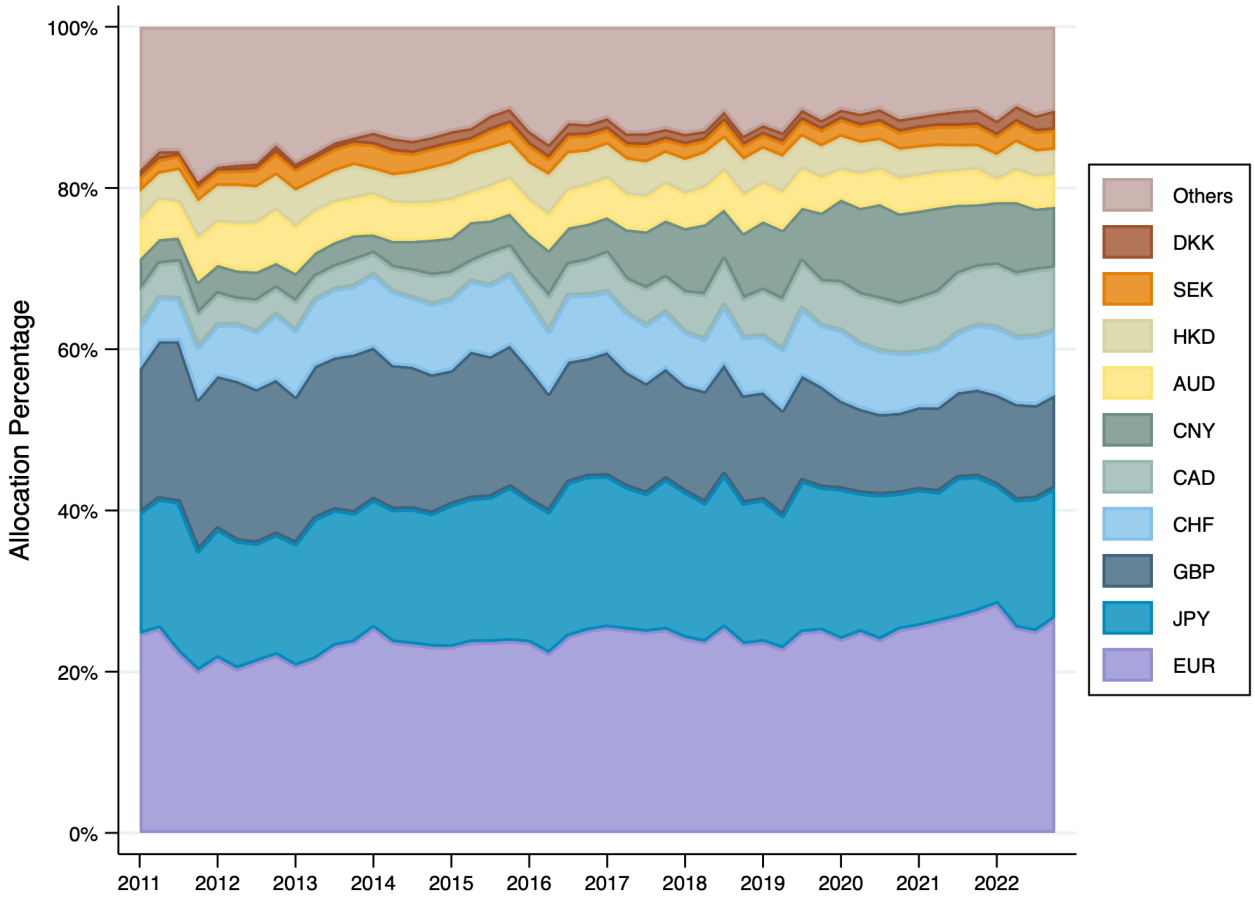


Figure 5: TDF Rebalancing Flow Impact Per Currency

This figures show the estimated coefficients on $RebFlow_{c,q-1}$ from Equation (14) when estimating it separately for the main currencies or regions (we group in geographical regions the smaller currencies in TDF portfolios). The currency of each firm is based on its main trading currency. Latin America includes ARS, BRL, CLP, COP, MXN and PEN currencies. Eastern Europe includes CZK, HUF, ILS, PLN, RUB, and TRY currencies. Nordic includes DKK, NOK, and SEK currencies. Asia includes IDR, INR, KRW, MYR, PHP, SGD, THB, and TWD currencies. The x-axis shows the TDF ownership as a percentage of the total market capitalization of each currency at the end of 2021.

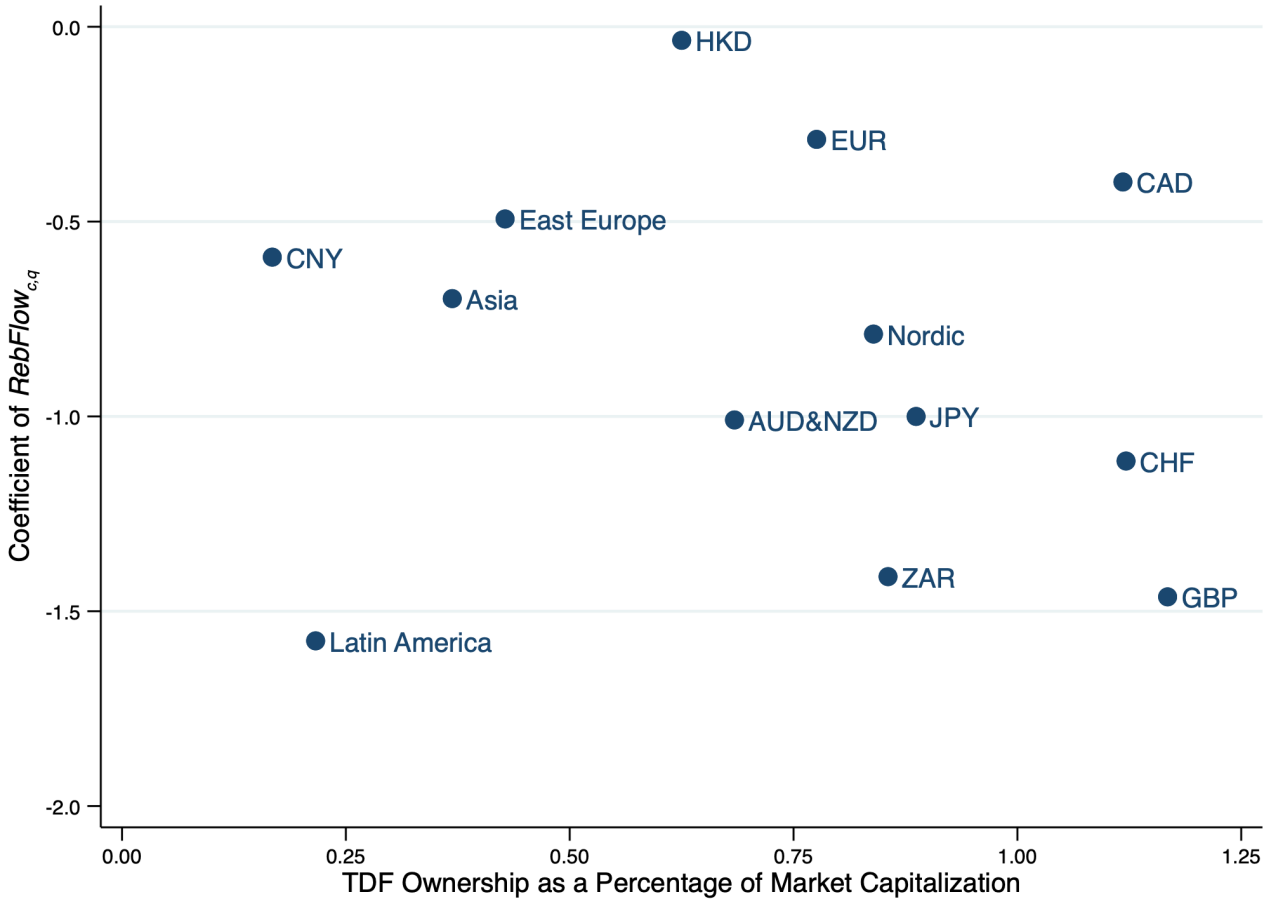


Table 1: Summary Statistics: TDFs

This table reports summary statistics on TDF-quarter level variables from 2011Q1 to 2022Q4. The TDFs column shows the number of unique TDFs. Panel A presents statistics on TDF fund variables, including TDF fund size (*TDF TNA*) in billion dollars, total size across TDFs in a series with same managers but different target retirement years (*TDF Series TNA*) in billion dollars, target retirement year of the TDF (*Target year*), years from current calendar year to retirement (*Years to Retirement*), quarterly net raw return of the TDF in percentage points (*TDF Return*), TDFs with more than 50% of their assets invested in index funds (*Passive TDF*), number of unique mutual funds held by a TDF (*#MF Held*), and percentage of a TDF's investment in mutual funds (*%MF Share*). Panel B presents TDF's actual asset allocation in domestic equity, foreign equity, fixed income, and cash in percent. Panel C reports TDF's target asset allocation to domestic equity, foreign equity, and fixed income in percent. Most TDFs do not distinguish between fixed income and cash in their target allocation so we combine these two categories. Panel D presents two TDF rebalancing measures. $RebalFlow_{k,q}^{FE}$ is calculated as the difference between TDF's total foreign equity trade and flow-driven trade scaled by the lagged total net assets. $ResidRebalFlow_{k,q}^{FE-DE}$ equals the difference between the rebalancing flow and a hypothetical rebalancing flow that reverts 100% of the mechanical changes in weights between the total equity and fixed income holdings. The rebalancing flow variables are winsorized at 1% level. $RebalWeight_{k,q}^{FE}$ is defined as the deviation of the actual foreign equity weight at quarter q from the counterfactual mechanical weight at quarter q if the TDF did not make any trades.. $RebalWeight_{k,q}^{FE-DE}$ is the relative rebalancing weight of foreign equity adjusted within the equity asset class.

	TDFs	Obs.	Mean	p25	Median	p75	SD
Panel A: TDF Fund Statistics							
TDF TNA ($ billion)	705	13,682	2.54	0.07	0.32	1.59	6.25
TDF Series TNA ($ billion)	705	13,682	37.00	0.97	4.50	27.51	93.90
Target Year	663	12,802	2034	2020	2035	2045	15
Years to Retirement	663	12,802	17	5	17	29	15
TDF Return	705	13,682	1.57	-0.36	2.34	4.84	6.26
Passive TDF	705	13,682	0.33	0.00	0.00	1.00	0.47
#MF Held	705	13,682	15.80	9.00	16.00	21.00	8.42
%MF Share	705	13,682	96.22	94.08	97.92	99.84	5.28
Panel B: TDF Actual Asset Allocation							
%Domestic Equity	705	13,682	45.90	34.34	48.67	58.42	15.59
%Foreign Equity	705	13,682	25.11	16.83	24.83	31.16	11.33
%Fixed Income and Cash	705	13,682	29.00	10.00	24.27	45.32	21.10
Panel C: TDF Target Asset Allocation							
%Domestic Equity	363	8,688	46.58	35.40	50.00	58.99	14.98
%Foreign Equity	363	8,688	21.08	14.04	21.10	27.00	8.48
%Fixed Income and Cash	363	8,688	32.34	11.00	27.60	49.50	21.61
Panel D: TDF Rebalancing Measures							
$RebalFlow_{k,q}^{FE}$	705	13,682	0.11	-0.47	0.06	0.75	1.58
$ResidRebalFlow_{k,q}^{FE-DE}$	705	13,682	0.27	-0.10	0.24	0.76	1.36
$RebalWeight_{k,q}^{FE}$	705	13,682	0.82	-0.36	0.53	1.83	2.07
$RebalWeight_{k,q}^{FE-DE}$	705	13,682	0.35	-0.17	0.37	1.10	2.30

Table 2: Summary Statistics: International Mutual Funds and Stocks

This table presents summary statistics of mutual fund level variables (Panel A) and stocks level variables (Panel B) from 2011Q1 to 2022Q4. In Panel A, we divide all U.S.based foreign equity mutual funds in the CRSP Mutual Fund Dataset into two categories: those with TDF ownership and those without any TDF ownership. TDF ownership is defined as the market value of mutual funds owned directly by TDFs. $FundFlow_q$ is the total mutual fund flow scaled by the fund size. Fund size and fund family size are measured in billion dollars. Cash share is the percentage of cash hold by the mutual fund. Expense ratio is obtained on an annual basis. In Panel B, we divide foreign stocks that have ever owned by TDFs from Compustat Global and North America Dataset into those with high TDF ownership and with low TDF ownership. TDF ownership is defined as the market value of the stock owned by all TDFs indirectly. Other mutual fund ownership is defined as the share owned by U.S. based mutual funds without any TDF ownership. All mutual fund ownership is defined as the share owned by all U.S. based mutual funds. Stock quarterly return is reported in USD dollars. Market capitalization is measured in billion dollars, quarterly trading volume is normalized by the number of shares outstanding. Dividend yield is the trailing 12-month cash dividend per shared divided by the share price in USD dollars. ROE is net income (revenue-COGS-SG&A-interest expense) divided by lagged book value of common shares in USD dollars. Investment ratio is the quarterly growth rate in total assets. Illiquidaty is the quarterly average of (Amihud, 2002) daily illiquidity measure in USD dollars.

Panel A: Foreign Equity Mutual Funds

	All (Obs.: 63,675)			With TDF ownership (Obs.: 6,875)			Without TDF ownership (Obs.: 56,800)		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
%TDF Ownership	2.32	0.00	11.77	21.53	5.10	29.47	0.00	0.00	0.00
MF Flow	2.15	-0.48	18.89	2.04	0.36	13.71	2.16	-0.60	19.42
MF Return	1.21	2.36	9.59	1.15	2.34	8.71	1.22	2.36	9.69
MF TNA ($ billion)	2.28	0.28	11.39	11.46	1.59	31.71	1.17	0.22	3.50
MF Family TNA ($ billion)	452.80	78.90	921.06	795.54	262.77	1254.14	411.32	68.36	862.99
MF Age	13	10	9	14	12	9	12	10	9
%Cash	1.70	0.71	6.91	1.45	0.75	5.97	1.73	0.71	7.02
Expense Ratio	0.96	0.98	0.47	0.78	0.86	0.41	0.98	0.99	0.47

Panel B: Foreign Stocks

	All (Obs.: 144,284)			High TDF ownership (Obs.: 72,152)			Low TDF ownership (Obs.: 73,132)		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
%TDF Ownership	0.31	0.12	0.55	0.58	0.40	0.67	0.04	0.00	0.07
%Other MF Ownership	2.54	1.59	4.62	4.07	3.17	5.80	1.02	0.38	2.10
%Total MF Ownership	4.56	3.03	7.80	7.69	6.31	9.80	1.42	0.60	2.40
Stock Return	2.91	1.02	146.72	1.82	1.44	19.88	3.99	0.52	206.55
Market Cap ($ billion)	6.55	1.49	28.24	9.18	2.95	22.49	3.93	0.60	32.80
Turnover	32.49	0.16	205.88	24.60	0.19	115.03	40.38	0.12	267.25
Market-to-Book Ratio	3.78	0.93	444.47	2.75	1.16	33.78	4.81	0.76	627.72
Dividend Yield	3.21	1.91	21.14	3.10	2.24	8.61	3.31	1.40	28.63
ROE	-4.25	5.47	4432.62	10.16	6.25	102.23	-18.66	4.62	6268.26
Investment	12.69	0.16	2575.11	3.06	0.27	24.41	22.31	0.04	3641.91
Illiquidity	0.02	0.01	0.07	0.01	0.00	0.03	0.03	0.01	0.09

Table 3: TDF Rebalancing of Foreign Equity

In this table, observations are at the TDF-quarter level. In Columns (1) to (3), the dependent variable $RebalFlow^{FE}_{k,q}$ is the actual rebalancing flow to foreign equity scaled by TDF's assets under management at the end of the previous quarter. In Columns (4) to (6), the dependent variable $RebalWeight^{FE}_{k,q}$ is the TDF rebalancing weight in foreign equity. $Pred.rebal^{FE-DE}_{k,q}$ and $Pred.rebal^{FE-DE}_{k,q-1}$ are the predicted quarterly rebalancing flow to foreign equity from domestic equity or fixed income based on the benchmark return difference and the actual allocation weight at the end of the previous quarter. Benchmark returns $R^{DE}_{Bench,q}$, $R^{FE}_{Bench,q}$ and $R^{FI}_{Bench,q}$ are the CRSP value-weighted U.S equity return, Vanguard Total International Stock Index Fund return, and Vanguard Total Bond Market Index Fund return. $R^{DE}_{Fund,q}$, $R^{FE}_{Fund,q}$, and $R^{FI}_{Fund,q}$ are value-weighted returns of a TDF's underlying domestic equity, foreign equity, and fixed income mutual funds. Control variables include the lagged quarter's log TDF assets, log series size, cash allocation share, current quarter's TDF flow rate, TDF quarterly return, and years to target retirement year. The specifications include TDF fixed effects. We double-cluster the standard errors by TDF and quarter, and report standard errors in brackets. $*p < .10$; $**p < .05$; $***p < .01$.

	$RebalFlow^{FE}_{k,q}$			$RebalWeight^{FE}_{k,q}$		
	(1)	(2)	(3)	(4)	(5)	(6)
$Pred.rebal^{FE-DE}_{k,q}$	0.526***			0.575***		
	(0.068)			(0.063)		
$Pred.rebal^{FE-DE}_{k,q-1}$	0.090			0.151*		
	(0.112)			(0.083)		
$Pred.rebal^{FE-FI}_{k,q}$	0.718***			0.255***		
	(0.083)			(0.089)		
$Pred.rebal^{FE-FI}_{k,q-1}$	0.075			0.082		
	(0.112)			(0.115)		
$(R^{FE}_{Bench,q} - R^{DE}_{Bench,q})$		-0.057***			-0.067***	
		(0.012)			(0.014)	
$(R^{FE}_{Bench,q-1} - R^{DE}_{Bench,q-1})$		-0.019			-0.026**	
		(0.016)			(0.013)	
$(R^{FE}_{Bench,q} - R^{FI}_{Bench,q})$		-0.046***			-0.017	
		(0.015)			(0.014)	
$(R^{FE}_{Bench,q-1} - R^{FI}_{Bench,q-1})$		-0.000			-0.001	
		(0.006)			(0.006)	
$(R^{FE}_{Fund,q} - R^{DE}_{Fund,q})$			-0.051***			-0.071***
			(0.019)			(0.016)
$(R^{FE}_{Fund,q-1} - R^{DE}_{Fund,q-1})$			-0.008			-0.021*
			(0.016)			(0.012)
$(R^{FE}_{Fund,q} - R^{FI}_{Fund,q})$			-0.082***			-0.024
			(0.027)			(0.016)
$(R^{FE}_{Fund,q-1} - R^{FI}_{Fund,q-1})$			-0.002			-0.002
			(0.008)			(0.008)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
TDF FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13,215	13,215	13,215	13,215	13,215	13,215
Adjusted R^2	0.124	0.095	0.134	0.581	0.575	0.580

Table 4: TDF Residual Rebalancing of Foreign Equity

In this table, observations are at the TDF-quarter level. In Columns (1) to (3), the dependent variable $ResidRebalFlow_{k,q}^{FE-DE}$ equals the difference between the rebalancing flow and a hypothetical rebalancing flow that reverts 100% of the mechanical changes in weights between the total equity and fixed income holdings. In Columns (4) to (6), the dependent variable $RebalWeight_{k,q}^{FE-DE}$ is the relative rebalancing weight of foreign equity adjusted within the equity asset class. $Pred.rebal_{k,q}^{FE-DE}$ and $Pred.rebal_{k,q-1}^{FE-DE}$ are the predicted quarterly rebalancing flow to foreign equity from domestic equity or fixed income based on the benchmark return difference and the actual allocation weight at the end of the previous quarter. Benchmark returns $R_{Bench,q}^{DE}$, $R_{Bench,q}^{FE}$ and $R_{Bench,q}^{FI}$ are the CRSP value-weighted U.S equity return, Vanguard Total International Stock Index Fund return, and Vanguard Total Bond Market Index Fund return. $R_{Fund,q}^{DE}$, $R_{Fund,q}^{FE}$, and $R_{Fund,q}^{FI}$ are value-weighted returns of a TDF's underlying domestic equity, foreign equity, and fixed income mutual funds. Control variables include the lagged quarter's log TDF assets, log series size, cash allocation share, current quarter's TDF flow rate, TDF quarterly return, and years to target retirement year. The specifications include TDF fixed effects. We double-cluster the standard errors by TDF and quarter, and report standard errors in brackets. $^{*}p < .10$; $^{**}p < .05$; $^{***}p < .01$.

	$ResidRebalFlow_{k,q}^{FE-DE}$			$RebalWeight_{k,q}^{FE-DE}$		
	(1)	(2)	(3)	(4)	(5)	(6)
$Pred.rebal_{k,q}^{FE-DE}$	0.610***			0.691***		
	(0.050)			(0.064)		
$Pred.rebal_{k,q-1}^{FE-DE}$	0.145**			0.190**		
	(0.063)			(0.075)		
$Pred.rebal_{k,q}^{FE-FI}$	-0.009			0.081		
	(0.054)			(0.091)		
$Pred.rebal_{k,q-1}^{FE-FI}$	-0.050			-0.063		
	(0.045)			(0.075)		
$(R_{Bench,q}^{FE} - R_{Bench,q}^{DE})$		-0.076***			-0.083***	
		(0.008)			(0.013)	
$(R_{Bench,q-1}^{FE} - R_{Bench,q-1}^{DE})$		-0.024***			-0.031**	
		(0.008)			(0.013)	
$(R_{Bench,q}^{FE} - R_{Bench,.,q}^{FI})$		0.002			-0.009	
		(0.008)			(0.011)	
$(R_{Bench,q-1}^{FE} - R_{Bench,q-1}^{FI})$		0.005			0.007	
		(0.003)			(0.005)	
$(R_{Fund,q}^{FE} - R_{Fund,q}^{DE})$			-0.072***			-0.094***
			(0.011)			(0.014)
$(R_{Fund,q-1}^{FE} - R_{Fund,q-1}^{DE})$			-0.018**			-0.035**
			(0.009)			(0.013)
$(R_{Fund,q}^{FE} - R_{Fund,q}^{FI})$			-0.020			-0.023*
			(0.013)			(0.013)
$(R_{Fund,q-1}^{FE} - R_{Fund,q-1}^{FI})$			0.005			0.008
			(0.004)			(0.005)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
TDF FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13,215	13,215	13,215	13,215	13,215	13,215
Adjusted R^2	0.102	0.089	0.106	0.062	0.056	0.076

Table 5: TDF Target Allocation to Foreign Equity

In this table, observations are at the TDF-quarter level. In Columns (1) to (3), the dependent variable $\omega^{FE}_{target,q}$ is the TDF's target asset allocation to foreign equity. In Columns (4) to (6), the dependent variable, $\Delta\omega^{FE}_{target,q}$ is the quarterly change in TDF's foreign equity asset allocation weight. $Pred.rebal^{FE-DE}_{k,q}$ and $Pred.rebal^{FE-DE}_{k,q-1}$ are the predicted quarterly rebalancing flow to foreign equity from domestic equity or fixed income based on the benchmark return difference and the actual allocation weight at the end of the previous quarter. Benchmark returns $R^{DE}_{Bench,q}$, $R^{FE}_{Bench,q}$ and $R^{FI}_{Bench,q}$ are the CRSP value-weighted U.S equity return, Vanguard Total International Stock Index Fund return, and Vanguard Total Bond Market Index Fund return. $R^{DE}_{Fund,q}$, $R^{FE}_{Fund,q}$, and $R^{FI}_{Fund,q}$ are value-weighted returns of a TDF's underlying domestic equity, foreign equity, and fixed income mutual funds. Control variables include the lagged quarter's log TDF assets, log series size, cash allocation share, current quarter's TDF flow rate, TDF quarterly return, and years to target retirement year. The specifications include TDF fixed effects. We double-cluster the standard errors by TDF and quarter, and report standard errors in brackets. $^{*}p < .10$; $^{**}p < .05$; $^{***}p < .01$.

	$\omega^{FE}_{target,q}$			$\Delta\omega^{FE}_{target,q}$		
	(1)	(2)	(3)	(4)	(5)	(6)
$Pred.rebal^{FE-DE}_{k,q}$	0.038			-0.018		
	(0.173)			(0.106)		
$Pred.rebal^{FE-DE}_{k,q-1}$	0.158			0.020		
	(0.184)			(0.083)		
$Pred.rebal^{FE-FI}_{k,q}$	-0.157			0.020		
	(0.162)			(0.056)		
$Pred.rebal^{FE-FI}_{k,q-1}$	-0.030			0.211		
	(0.089)			(0.140)		
$(R^{FE}_{Bench,q} - R^{DE}_{Bench,q})$		0.007			0.014	
		(0.019)			(0.013)	
$(R^{FE}_{Bench,q-1} - R^{DE}_{Bench,q-1})$		0.008			0.003	
		(0.020)			(0.011)	
$(R^{FE}_{Bench,q} - R^{FI}_{Bench,,q})$		0.017			-0.008	
		(0.024)			(0.009)	
$(R^{FE}_{Bench,q-1} - R^{FI}_{Bench,q-1})$		-0.001			-0.014	
		(0.009)			(0.011)	
$(R^{FE}_{Fund,q} - R^{DE}_{Fund,q})$			-0.033			0.010
			(0.020)			(0.010)
$(R^{FE}_{Fund,q-1} - R^{DE}_{Fund,q-1})$			-0.021			0.008
			(0.019)			(0.012)
$(R^{FE}_{Fund,q} - R^{FI}_{Fund,q})$			0.039			-0.010
			(0.027)			(0.009)
$(R^{FE}_{Fund,q-1} - R^{FI}_{Fund,q-1})$			0.004			-0.020
			(0.010)			(0.014)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
TDF FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,441	8,441	8,441	8,441	8,441	8,441
Adjusted R^2	0.942	0.942	0.943	0.014	0.015	0.024

Table 6: TDF Rebalancing in Response to Foreign Equity Local Return and Currency Return

This table shows the results of a 2SLS analysis. $R^{FE}_{Fund,q}$ is the foreign equity underlying fund return of each TDF. $RebalFlow^{FE}_{k,q}$ is calculated as the difference between TDF's total foreign equity trade and flow-driven trade scaled by the lagged total net assets. $ResidRebalFlow^{FE-DE}_{k,q}$ equals the difference between the rebalancing flow and a hypothetical rebalancing flow that reverts 100% of the mechanical changes in weights between the total equity and fixed income holdings. The rebalancing flow variables are winsorized at 1% level. $RebalWeight^{FE}_{k,q}$ is defined as the deviation of the actual foreign equity weight at quarter q from the counterfactual mechanical weight at quarter q if the TDF did not make any trades. $RebalWeight^{FE-DE}_{k,q}$ is the relative rebalancing weight of foreign equity adjusted within the equity asset class. $R^{USD}_{Bench,q}$ is the return of USD relative to local currency, calculated as the return difference between MSCI ACWI ex USA USD gross index and MSCI ACWI ex USA local gross index. $R^{LocalEquity}_{Bench,q}$ is the MSCI ACWI ex USA local gross return. Panel A reports the first stage results of 2SLS regressions. Panel B reports the second stage results using rebalancing flow measurements as dependent variables. Panel C reports the second stage results using rebalancing weight measurements as dependent variables. Control variables include lagged quarter's log TDF TNA, log Series size, Cash share, and current quarter's TDF flow rate. TDF quarterly return, and Years to retirement. The specifications include TDF fixed effects. We double-cluster the standard errors by TDF and quarter, and report standard errors in brackets. $^*p < .10$; $^{**}p < .05$; $^{***}p < .01$.

Panel A: First Stage with Foreign Equity Return

	$R^{FE}_{Fund,q}$		
	(1)	(2)	(3)
$R^{USD}_{Bench,q}$	0.646***		0.945***
	(0.123)		(0.042)
$R^{LocalEquity}_{Bench,q}$		0.687***	0.920***
		(0.126)	(0.044)
Controls	Yes	Yes	Yes
TDF FE	Yes	Yes	Yes
Observations	13,215	13,215	13,215
Adjusted R^2	0.874	0.892	0.964

Panel B: Second Stage with Rebalancing Flow Dependent Variables

	$RebalFlow^{FE}_{k,q}$			$ResidRebalFlow^{FE-DE}_{k,q}$		
	(1)	(2)	(3)	(1)	(2)	(3)
$R^{FE}_{Fund,q}$	-0.086***	-0.118***	-0.105***	-0.078***	-0.035***	-0.053***
	(0.008)	(0.008)	(0.006)	(0.007)	(0.005)	(0.004)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
TDF FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13,229	13,229	13,229	13,229	13,229	13,229
Adjusted R^2	0.125	0.137	0.133	0.080	0.064	0.076

Panel C: Second Stage with Rebalancing Weight Dependent Variables

	$RebalWeight^{FE}_{k,q}$			$RebalWeight^{FE-DE}_{k,q}$		
	(1)	(2)	(3)	(1)	(2)	(3)
$R^{FE}_{Fund,q}$	-0.051***	-0.050***	-0.050***	-0.085***	-0.063***	-0.072***
	(0.008)	(0.008)	(0.006)	(0.009)	(0.008)	(0.006)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
TDF FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13,229	13,229	13,229	13,229	13,229	13,229
Adjusted R^2	0.566	0.566	0.566	0.050	0.047	0.049

Table 7: TDF Ownership and Flows to Foreign Equity Mutual Funds

In this table, observations are at the mutual-fund-quarter level. The dependent variable $MFflow_{i,q}$ is the mutual fund flow scaled by the fund's assets under management at the end of the previous quarter. Benchmark returns $R^{DE}_{Bench,q}$, $R^{FE}_{Bench,q}$ and $R^{FI}_{Bench,q}$ are the CRSP value-weighted U.S equity return, Vanguard Total International Stock Index Fund return, and Vanguard Total Bond Market Index Fund return. $R_{i,q}$ is the mutual fund return at quarter q. $\%TDF_{i,q-1}$ is the TDF ownership in mutual fund i. Control variables include the lagged log mutual fund size, lagged log mutual fund family size, current log mutual fund age, current cash allocation share, and current expense ratio. We include mutual fund fixed effects in all specifications as well as quarter-time fixed effects in Columns (5) and (6). We double-cluster the standard errors by mutual fund and quarter, and report standard errors in brackets. $^*p < .10$; $^{**}p < .05$; $^{***}p < .01$.

	$MFflow_{i,q}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$(R^{FE}_{Bench,q} - R^{DE}_{Bench,q})$	0.140	0.151				
	(0.091)	(0.094)				
$(R^{FE}_{Bench,q-1} - R^{DE}_{Bench,q-1})$	0.178*	0.190*				
	(0.101)	(0.104)				
$(R^{FE}_{Bench,q} - R^{DE}_{Bench,q}) \times \%TDF_{i,q-1}$		-0.506***				
		(0.169)				
$(R^{FE}_{Bench,q-1} - R^{DE}_{Bench,q-1}) \times \%TDF_{i,q-1}$		-0.508***				
		(0.168)				
$(R^{FE}_{Bench,q} - R^{FI}_{Bench,q})$			0.094***	0.101***		
			(0.028)	(0.029)		
$(R^{FE}_{Bench,q-1} - R^{FI}_{Bench,q-1})$			0.172***	0.177***		
			(0.033)	(0.035)		
$(R^{FE}_{Bench,q} - R^{FI}_{Bench,q}) \times \%TDF_{i,q-1}$				-0.292***		
				(0.091)		
$(R^{FE}_{Bench,q-1} - R^{FI}_{Bench,q-1}) \times \%TDF_{i,q-1}$				-0.189**		
				(0.078)		
$R_{i,q}$					0.303***	0.306***
					(0.036)	(0.036)
$R_{i,q-1}$					0.408***	0.411***
					(0.045)	(0.045)
$R_{i,q} \times \%TDF_{i,q-1}$						-0.321***
						(0.085)
$R_{i,q-1} \times \%TDF_{i,q-1}$						-0.254**
						(0.100)
$\%TDF_{i,q-1}$	0.030**	0.011	0.029**	0.034**	0.029*	0.036**
	(0.015)	(0.016)	(0.015)	(0.016)	(0.015)	(0.016)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Mutual Fund FE	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	No	No	No	No	Yes	Yes
Observations	62,919	62,919	62,919	62,919	62,919	62,919
Adjusted R^2	0.173	0.173	0.178	0.179	0.206	0.207

Table 8: TDF Ownership and Stock Comovements

In this table, observations are at the foreign-stock-quarter level. The sample includes all foreign stocks that have ever been owned by a TDF during the 2011Q1–2022Q4 period. The dependent variables measure the beta of stock returns to the difference in benchmark returns between foreign equities and other asset classes in the TDF portfolio. In Columns (1) and (3), these betas are obtained by estimating the following model $R^{USD}_{s,m} = a_{s,m} + b_{s,m}X_m + \epsilon_{s,m}$ on a stock level using monthly data and 3-years rolling windows. The dependent variables in Columns (2) and (4) are obtained from equation $R^{USD}_{s,m} = a_{s,m} + b^{'}_{s,m}X_m + c_{s,m}X_{m-1} + \epsilon_{s,m}$, estimated also on a stock level using monthly data and 3-years rolling windows. In these specifications, X_m is return difference $(R^{FE}_{Bench,q} - R^{DE}_{Bench,q})$ in Columns (1) and (2), and $(R^{FE}_{Bench,q} - R^{FI}_{Bench,q})$ in Columns (3) and (4). Benchmark returns $R^{DE}_{Bench,q}$, $R^{FE}_{Bench,q}$ and $R^{FI}_{Bench,q}$ are the CRSP value-weighted U.S equity return, Vanguard Total International Stock Index Fund return, and Vanguard Total Bond Market Index Fund return. $\%TDF_{s,q-1}$ is the lagged TDF ownership in stock s in quarter $q-1$. $\%OMF_{s,q-1}$ is the lagged ownership of stock s by other (non-TDF) U.S. foreign equity mutual funds, which enables us to isolate the effect of TDF ownership from other mutual fund investors. Stock-level control variables include the lagged quarter stock return, log of lagged values of market capitalization, turnover, market-to-book ratio, and lagged values of dividend yield, ROE, investment, and illiquidity. Country-level control variables include lagged stock market capitalization, GDP, CPI, interest rate, developed country indicator, local market stock return, and local stock market volatility. Currency-level control variables include the lagged 1-quarter to 4-quarter exchange rate change and exchange rate volatility. The specifications also include the lagged ACWI ex-US index quarterly return and volatility. The specifications include stock fixed effects. We triple-cluster the standard errors by stock, country, and quarter, and report standard errors in brackets. $^*p < .10$; $^{**}p < .05$; $^{***}p < .01$.

	$\hat{b}^{FE-DE}_{s,q}$ (1)	$\hat{b}'^{FE-DE}_{s,q}$ (2)	$\hat{b}^{FE-FI}_{s,q}$ (3)	$\hat{b}'^{FE-FI}_{s,q}$ (4)
$\%TDF_{s,q-1}$	-0.343***	-0.336***	0.001	0.001
	(0.076)	(0.079)	(0.071)	(0.072)
$\%OMF_{s,q-1}$	-0.006	-0.006	-0.005	-0.005
	(0.006)	(0.006)	(0.004)	(0.005)
Stock-Level Controls	Yes	Yes	Yes	Yes
Country-Level Controls	Yes	Yes	Yes	Yes
Currency-Level Controls	Yes	Yes	Yes	Yes
ACWI ex US Index Return	Yes	Yes	Yes	Yes
ACWI ex US Index Volatility	Yes	Yes	Yes	Yes
Stock FE	Yes	Yes	Yes	Yes
Observations	131,700	131,700	131,700	131,700
Adjusted R^2	0.284	0.279	0.233	0.231

Table 9: TDF Rebalancing Flows and Exchange Rates (Currency Level)

Observations in this table are at the currency quarter level. Dependent variable $\Delta FX_{c,q}$ is the change of the exchange rate, measured as foreign currency value per US dollar. $RebFlow_{c,q-1}$ is the aggregate rebalancing flow from TDFs to currency c in quarter $q-1$ measures in \$ billions. $ResidRebalFlow_{c,q-1}^{FE-DE}$ equals the difference between the rebalancing flow and a hypothetical rebalancing flow that reverts 100% of the mechanical changes in weights between the total equity and fixed income holdings. $RebFlow_{c,q-1}/MV_{c,q-1}$ and $ResidRebalFlow_{c,q-1}^{FE-DE}/MV_{c,q-1}$ are the total rebalancing flow and residual rebalancing flow scaled by total currency c market capitalization. $RebFlow_{c,q-1}/TDFMV_{c,q-1}$ and $ResidRebFlow_{c,q-1}^{FE-DE}/TDFMV_{c,q-1}$ are the total rebalancing flow and residual rebalancing flow scaled by the total equity holdings of TDFs in currency c. We also control for the lagged TDF and other foreign equity mutual funds ownership shares. Currency-level control variables include the lagged 1-quarter to 4-quarter exchange rate change and exchange rate volatility. The specifications also include the lagged ACWI ex-US index quarterly return and volatility. The specifications include currency-fixed effects. We cluster the standard errors by currency, and report standard errors in brackets. $^*p < .10$; $^{**}p < .05$; $^{***}p < .01$.

	$\Delta FX_{c,q}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$RebFlow_{c,q-1}$	-1.637**					
	(0.682)					
$ResidRebFlow_{c,q-1}^{FE-DE}$		-3.376***				
		(0.884)				
$RebFlow_{c,q-1}/MV_{c,q-1}$			-38.276***			
			(8.305)			
$ResidRebFlow_{c,q-1}^{FE-DE}/MV_{c,q-1}$				-50.661***		
				(14.039)		
$RebFlow_{c,q-1}/TDFMV_{c,q-1}$					-5.338**	
					(2.489)	
$ResidRebFlow_{c,q-1}^{FE-DE}/TDFMV_{c,q-1}$						-7.814
						(5.532)
$\%TDF_{c,q-1}$	-2.859**	-2.439*	-2.793**	-2.097	-3.066**	-3.162**
	(1.335)	(1.295)	(1.337)	(1.310)	(1.342)	(1.347)
$\%OMF_{c,q-1}$	0.101	0.111	0.115	0.098	0.109	0.107
	(0.281)	(0.281)	(0.279)	(0.274)	(0.277)	(0.278)
Currency-Level Controls	Yes	Yes	Yes	Yes	Yes	Yes
ACWI ex US Index Return	Yes	Yes	Yes	Yes	Yes	Yes
ACWI ex US Index Volatility	Yes	Yes	Yes	Yes	Yes	Yes
Currency FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,673	1,673	1,673	1,673	1,673	1,673
Adjusted R^2	0.123	0.125	0.128	0.126	0.123	0.124

Table 10: TDF Rebalancing Flows and Exchange Rates Using GIVs

Observations in this table are at the currency quarter level. In Columns (1) and (3), the first instrument $GIV1_{c,q}$ is calculated as the difference between the value-weighted rebalancing flow and the equal-weighted rebalancing flow at the country or currency level. The second instrument second $GIV2_{c,q}$ in Columns (2) and (4) is constructed as the residuals ($\varepsilon_{k,q}$) of a regression that predictable components of the rebalancing flows are taken out. $RebFlow_{c,q}$ in Columns (1) and (2) is the aggregate rebalancing flow from TDFs to currency c in quarter $q-1$ measures in \$ billions. $ResidRebalFlow_{c,q}^{FE-DE}$ in Columns (3) and (4) equals the difference between the rebalancing flow and a hypothetical rebalancing flow that reverts 100% of the mechanical changes in weights between the total equity and fixed income holdings. Dependent variable $\Delta FX_{c,q}$ in the second stage is the change of the exchange rate, measured as foreign currency value per US dollar. We also control for the lagged TDF and other foreign equity mutual funds ownership shares. Currency-level control variables include the lagged 1-quarter to 4-quarter exchange rate change and exchange rate volatility. The specifications also include the lagged ACWI ex-US index quarterly return and volatility. The specifications include currency-fixed effects. We cluster the standard errors by currency, and report standard errors in brackets. $^*p < .10$; $^{**}p < .05$; $^{***}p < .01$.

	Panel A: First Stage				**Panel B: Second Stage**			
	$RebFlow_{c,q}$		$ResidRebFlow_{c,q}^{FE-DE}$		$\Delta FX_{c,q}$			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
$GIV1_{c,q}$	5.034***		3.745***					
	(0.445)		(0.248)					
$GIV2_{c,q}$		13.068***		13.565***				
		(1.396)		(1.462)				
$RebFlow_{c,q-1}$					-1.566*	-0.336		
					(0.881)	(0.502)		
$ResidRebFlow_{c,q-1}^{FE-DE}$							-4.685**	-3.139***
							(2.139)	(1.032)
Observations	1,673	1,638	1,673	1,638	1,673	1,638	1,673	1,638
Adjusted R^2	0.315	0.280	0.574	0.626	0.118	0.119	0.122	0.124
F-value	58.28	35.01	147.9	77.02				
Currency-Level Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ACWI ex US Index Return	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ACWI ex US Index Volatility	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Currency FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Online Appendix

Target Date Funds and International Capital Flows

A.1 Calculation of Predicted Rebalancing Flow

In Section 3, we extend the analysis of a two-asset model (equity and fixed income) from Parker, Schoar, and Sun (2023) to our setting with a three-asset model (domestic equity, foreign equity, and fixed income), and calculate $Pred.rebal_{k,q}^{FE}$ as the predicted rebalancing flow to foreign equities.

We start by assuming that a TDF k has target asset allocation weight in foreign equity ($\omega_{k,q}^{FE}$) and in domestic equity ($\omega_{k,q}^{DE}$). Thereby, its target asset allocation in fixed income in quarter q is $(1-\omega_{k,q}^{FE}-\omega_{k,q}^{DE})$. The realized quarterly returns of domestic equity, foreign equity and fixed income are R_q^{DE}, R_q^{FE} and R_q^{FI}. Assuming that the TDF does not trade during quarter q, the post-returns of its domestic equity shares, foreign equity shares and fixed income shares at the end of quarter q are $\omega_{k,q-1}^{DE}(1+R_q^{DE})$, $\omega_{k,q-1}^{FE}(1+R_q^{FE})$ and $(1-\omega_{k,q-1}^{FE}-\omega_{k,q-1}^{DE})(1+R_q^{FI})$ respectively. We denote the total return as V_q, which is the sum of the returns on three asset classes:

$$V_q \equiv 1 + R_q^{FI} + \omega_{k,q-1}^{DE}(R_q^{DE} - R_q^{FI}) + \omega_{k,q-1}^{FE}(R_q^{FE} - R_q^{FI}) \tag{21}$$

We assume one scenario when there is no fund flows, and another scenario when there is fund flows F. In the first scenario, the TDF's desired holdings if it maintains its target allocation in quarter $q-1$ are $\omega_{k,q-1}^{DE}V_q$, $\omega_{k,q-1}^{FE}V_q$ and $(1-\omega_{k,q-1}^{FE}-\omega_{k,q-1}^{DE})V_q$ for domestic equity, foreign equity and fixed income. The total net purchases ($Pred.tot$) for these three assets are the differences between the desired holdings and the post-returns. For example, the total net purchase for foreign equity is calculated as follows:

$$\begin{aligned} Pred.tot_{k,q}^{FE} &= \omega_{k,q-1}^{FE}V_q - \omega_{k,q-1}^{FE}(1+R_q^{FE}) \\ &= \omega_{k,q-1}^{FE}[-(1-\omega_{k,q-1}^{FE})(R_q^{FE}-R_q^{FI}) + \omega_{k,q-1}^{DE}(R_q^{DE}-R_q^{FI})] \end{aligned} \tag{22}$$

Since the TDF receives no fund flow in quarter q, the flow-driven trade ($Pred.flow$) is 0 for three asset classes. The rebalancing trade ($Pred.reb$), which is defined as the residual trade of the total trade ($Pred.tot$) after subtracting the flow-driven trade ($Pred.flow$), equals the total trade in this case. That is, the

rebalancing trade in foreign equity ($Pred.tot^{FE}_{k,q}$) is $\omega^{FE}_{k,q-1}[-(1-\omega^{FE}_{k,q-1})(R^{FE}_q - R^{FI}_q) + \omega^{DE}_{k,q-1}(R^{DE}_q - R^{FI}_q)]$.

In the second scenario, we assume the TDF receives F_q fund flows at the end of quarter q. Under the assumtion that TDF does not change its target allocation weights, its desired holdings in this case become $\omega^{DE}_{k,q-1}(V_q + F_q)$, $\omega^{FE}_{k,q-1}(V_q + F_q)$ and $(1 - \omega^{FE}_{k,q-1} - \omega^{DE}_{k,q-1})(V_q + F_q)$ for domestic equity, foreign equity and fixed income. Thereby, the total trade in foreign equity becomes as follows:

$$\begin{aligned} Pred.tot^{FE}_{k,q} &= \omega^{FE}_{k,q-1}(V_q - F_q) - \omega^{FE}_{k,q-1}(1 + R^{FE}_q) \\ &= \omega^{FE}_{k,q-1}[-(1 - \omega^{FE}_{k,q-1})(R^{FE}_q - R^{FI}_q) + \omega^{DE}_{k,q-1}(R^{DE}_q - R^{FI}_q) - F_q] \end{aligned} \tag{23}$$

The flow-driven trade in foreign equity becomes $\omega^{FE}_{k,q-1}F_q$. As a result, the rebalancing trade in foreign equity ($Pred.tot^{FE}_{k,q}$) is as follows:

$$\begin{aligned} Pred.reb^{FE}_{k,q} &= Pred.tot^{FE}_{k,q} - Pred.flow^{FE}_{k,q} \\ &= -\omega^{FE}_{k,q-1}(1 - \omega^{FE}_{k,q-1})(R^{FE}_q - R^{FI}_q) + \omega^{FE}_{k,q-1}\omega^{DE}_{k,q-1}(R^{DE}_q - R^{FI}_q) \end{aligned} \tag{24}$$

Finally, we can rewrite Equation (24) and obtain Equation (8). In this paper, we adopt the second scenario, which assumes TDFs receive fund flows each quarter. They need to redistribute these flows while simultaneously maintain their original target allocation weights. Thus, TDFs' rebalancing flows in foreign equity are obtained from Equation (24).

Figure A.1: Assets in TDFs, Target Date CITs, and Balanced Funds

This figure presents the total assets under management of three types of funds from 2011Q1 to 2022Q4 in $ billion: Target Date Funds (TDFs), Collective investment trusts (CITs), and Balanced Funds. We extend the analysis of (Parker, Schoar, and Sun, 2023) and update the data on TDFs and BFs using the CRSP dataset, and the data of CITs using annual Morningstar TDF research reports.

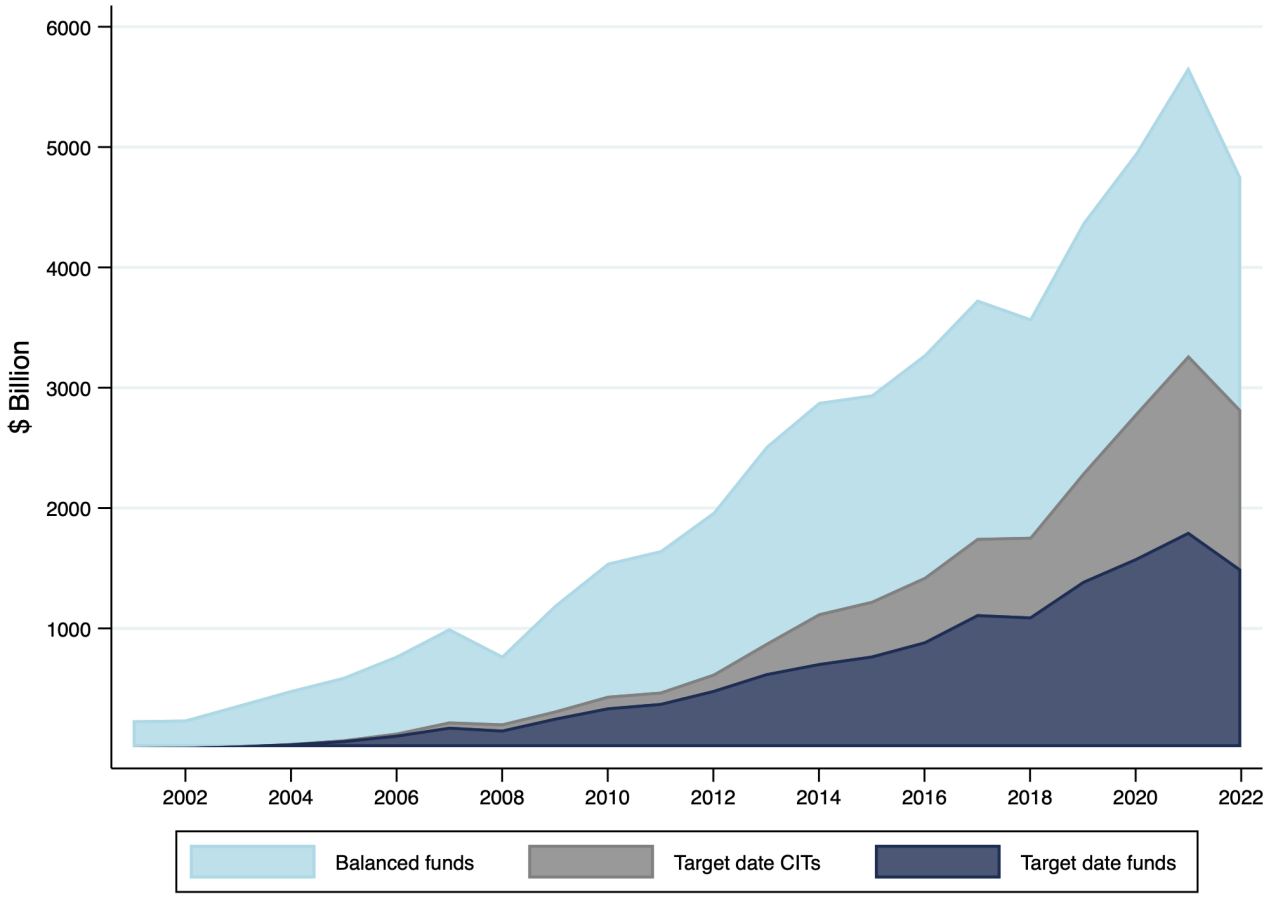


Figure A.2: TDF Asset Allocation

This figure presents the total assets under management of TDFs from 2011Q1 to 2022Q4 in $ trillion. We split the TDFs into four categories: TDFs that distinguish between domestic and foreign equity and have explicit target allocation weights to foreign equity, TDFs that have explicit target allocation weights to foreign equity and split between developed and emerging equity markets. TDFs without explicit target weights to foreign equity, and TDFs that do not disclose their target asset allocation (glide path) in the fund prospectuses.

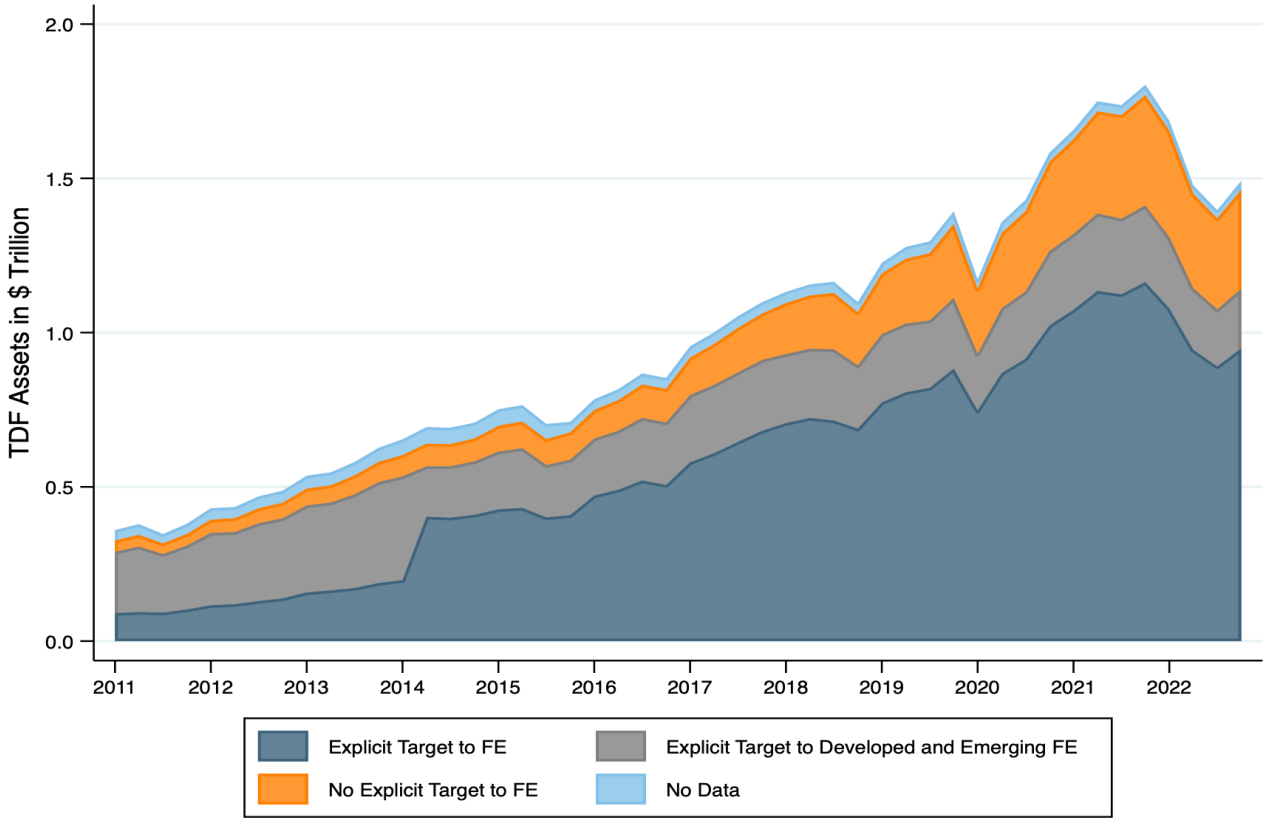


Figure A.3: TDF Ownership of U.S. (Foreign Equity) Mutual Fund Holdings

In this figure, Panel A shows the ownership of total asset under managements of TDFs among all U.S. mutual fund holdings. Panel B presents the U.S. foreign equity mutual fund shares owned by TDFs. All data are obtained from CRSP Mutual Fund Database.

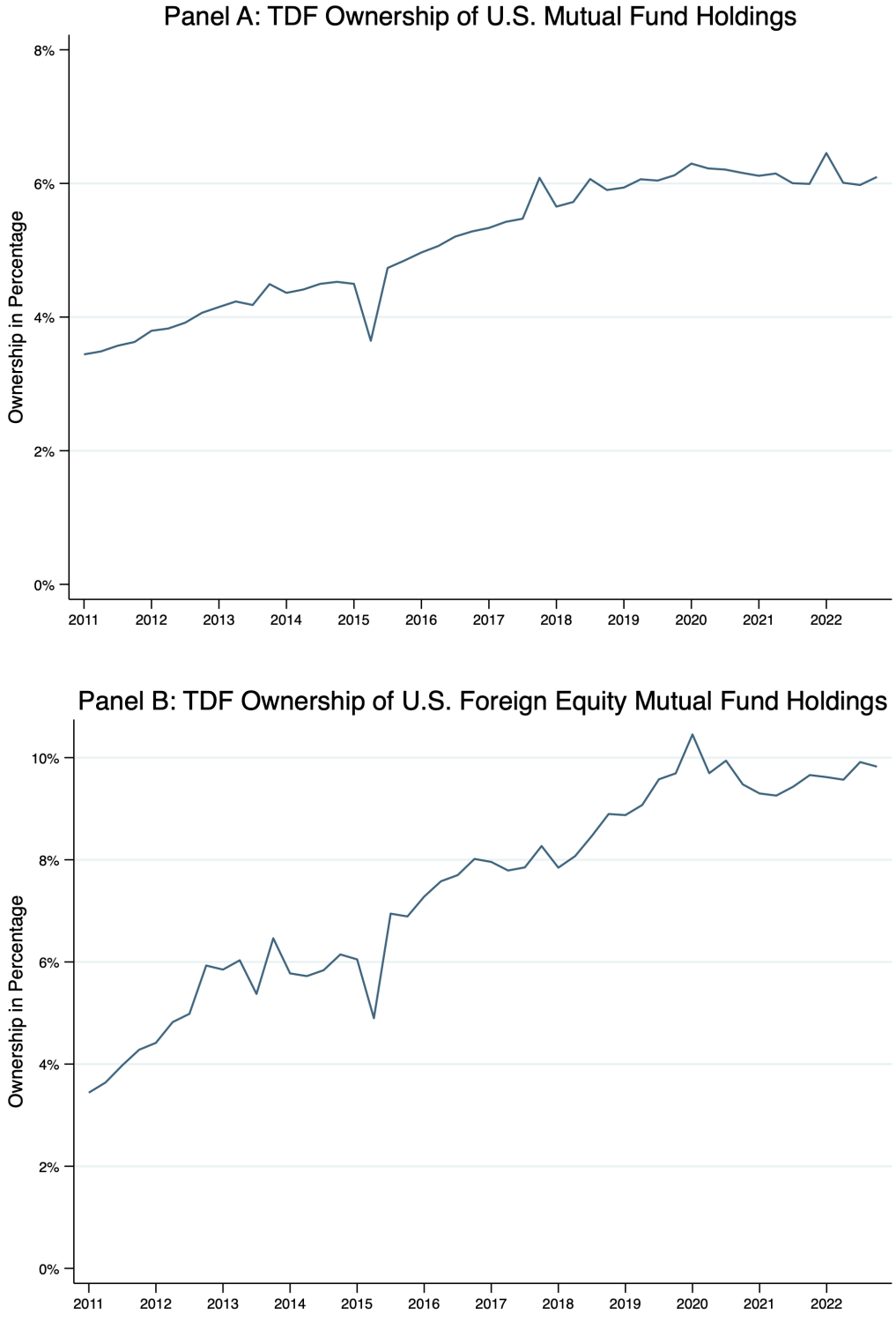


Figure A.4: TDF Ownership over GDP

These box graphs show the dispersions and ranges of TDF ownership over GDP from 2011 to 2022. For each stock, we calculate its market value owned by TDFs. We allocate each stock to one country based on the firm's headquarter location in Panel A, and the firm's incorporation location in Panel B. Both panels present TDF ownership as a percentage of s country's GDP. The lower and upper bounds of the box indicate $p25$ and $p75$. Outliers that are higher than $p25+3/2(p75-p25)$ or lower than $p25-3/2(p75-p25)$ are dropped.

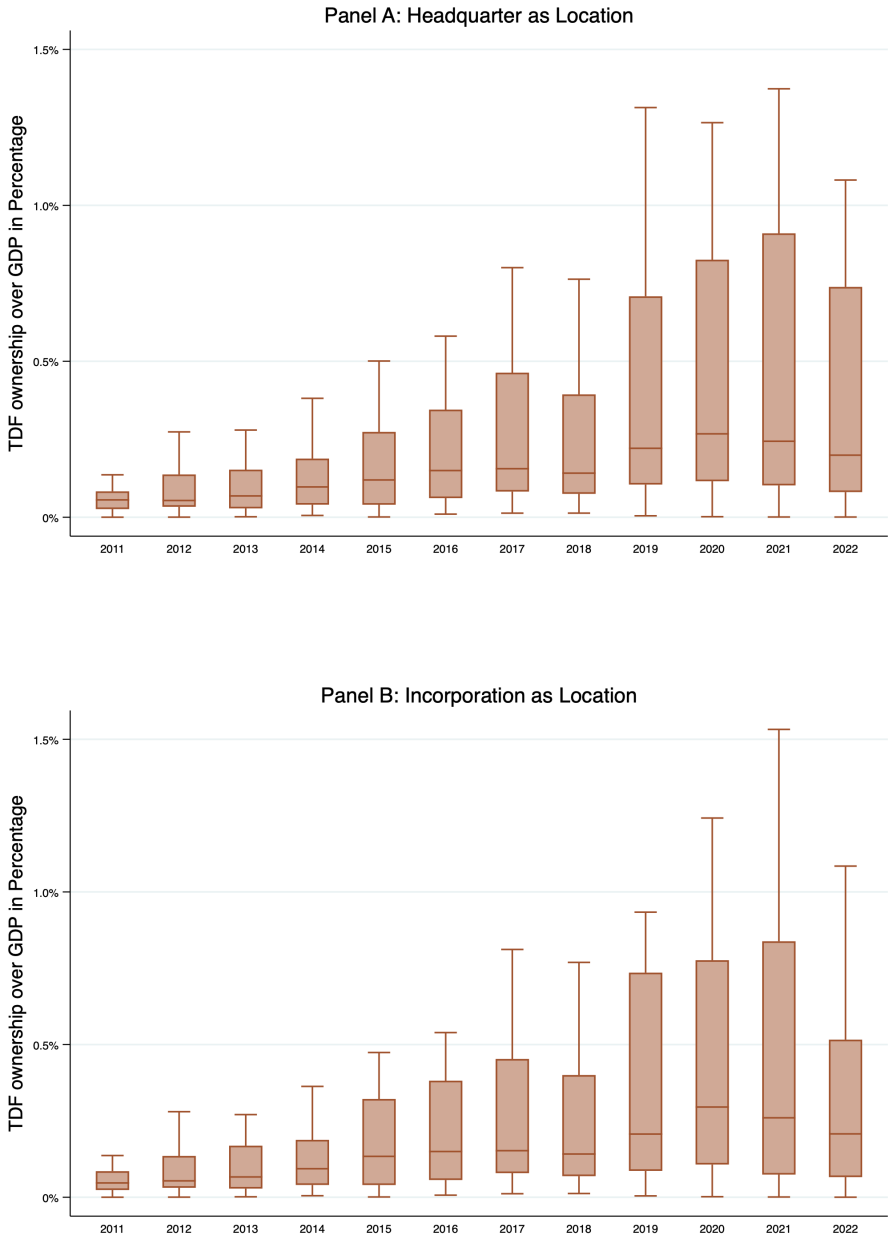


Figure A.5: TDF Ownership of Developed and Emerging Markets

These box graphs show the dispersions and ranges of TDF ownership from 2011 to 2022. For each stock, we calculate its total market value, the market value owned by TDFs and the market value owned by all U.S. based foreign equity mutual funds. We allocate each stock to one country based on the firm's headquarters. Panels A and B present TDF ownership as a percentage of the total market capitalization of each stock or country. In Panel C and Panel D, we present TDF ownership as a percentage of a country's GDP. TDF ownership of developed markets is shown in Panels A and B, and TDF ownership of emerging markets is shown in Panels C and D. The lower and upper bounds of the box indicate $p25$ and $p75$. Outliers that are higher than $p25 + 3/2(p75 - p25)$ or lower than $p25 - 3/2(p75 - p25)$ are dropped.

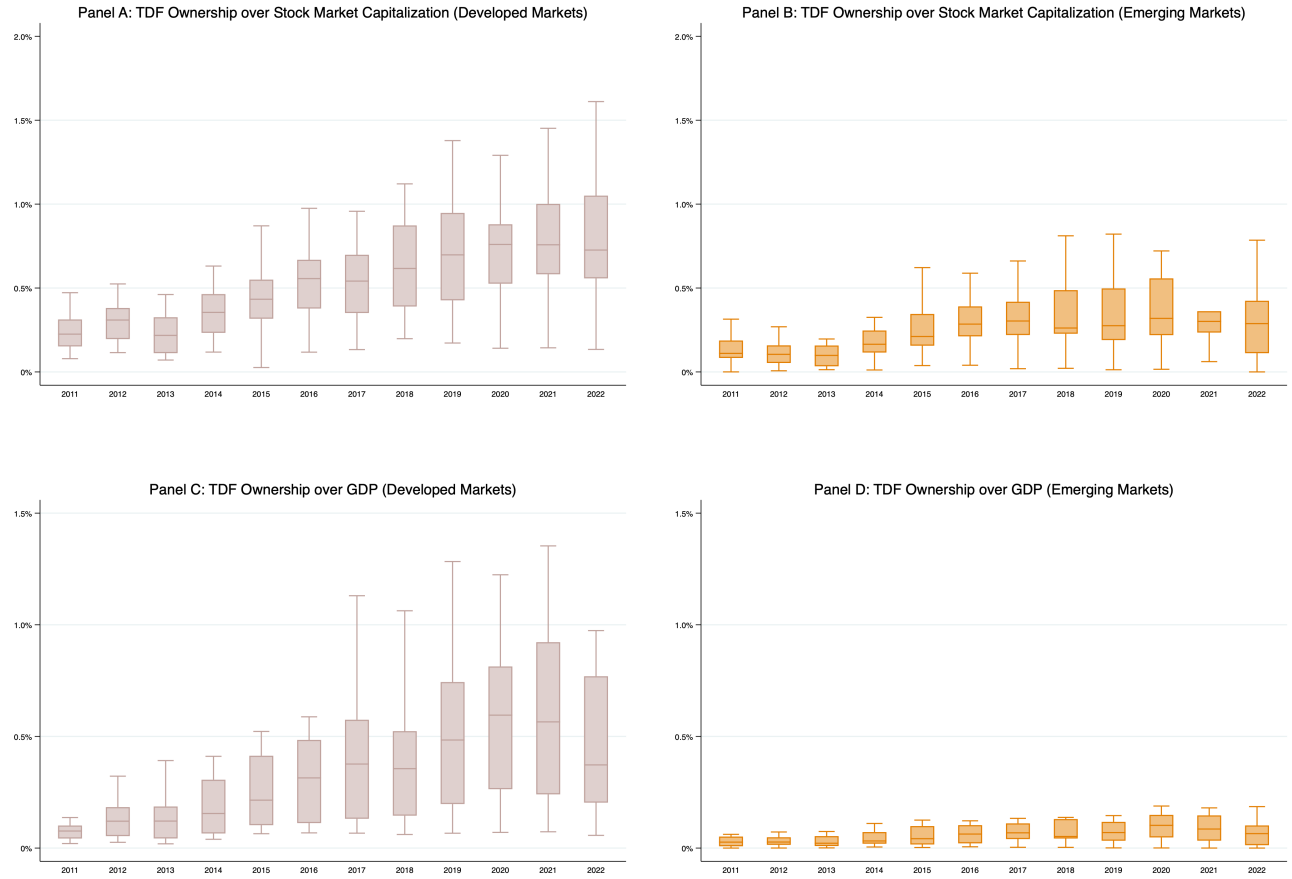


Figure A.6: TDF Ownership of Foreign Equities by U.S. and Non-U.S. Stocks

This figure splits the aggregate TDF foreign equity holdings by currency. We present the percentage allocation to the USD and all the others.We classify each stock into one currency based on the location of the firm's headquarters.

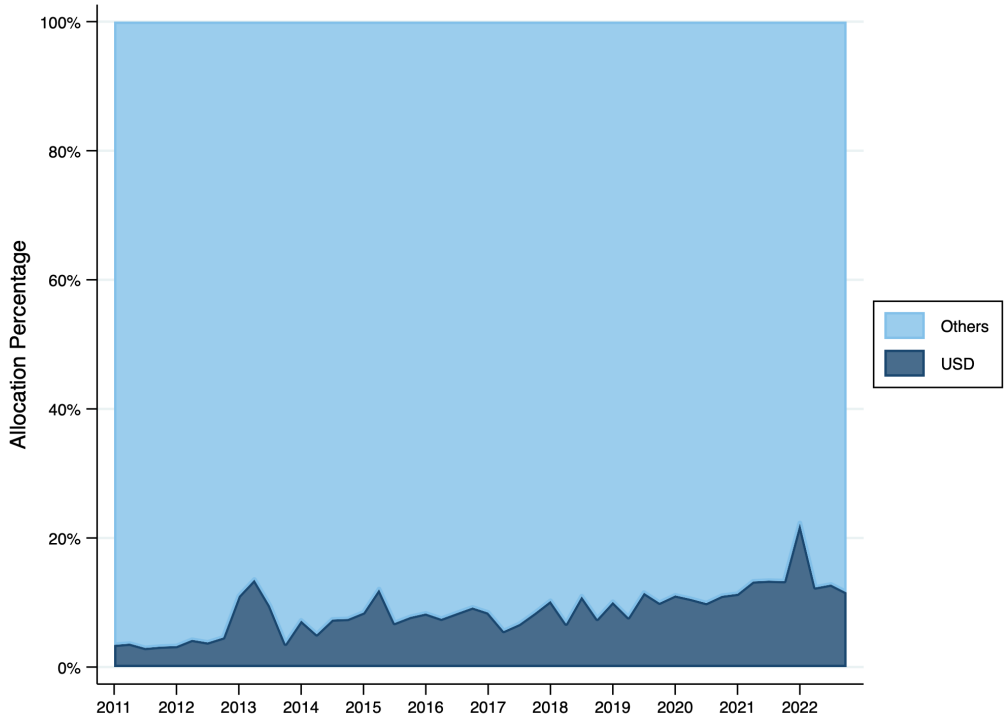


Figure A.7: TDF Ownership of Foreign Equities by Currency

This figure splits the aggregate TDF foreign equity holdings by currency. We present the percentage allocation to the 10 main currencies separately and combine all the others. The 10 main currencies are defined at the end of 2022Q4 but their allocation share is relatively constant over time. We classify each stock into one currency based on the location of the firm's incorporation in Panel A and the firm' main trading currency in Panel B.

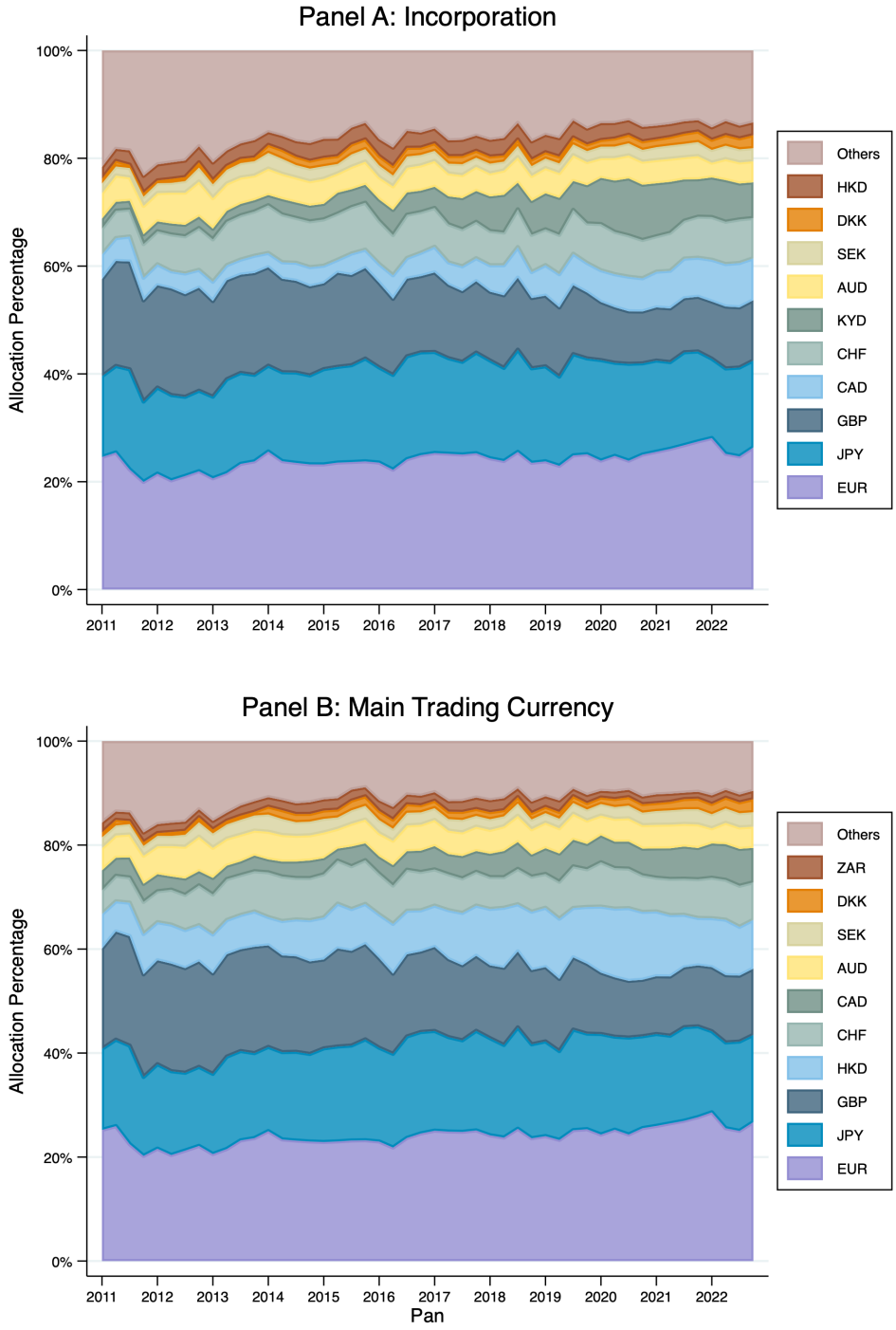


Table A.1: Passive TDF Rebalancing of Foreign Equity

Robustness test of Table 3: We analyze the rebalancing flows and weights of the subsample of passive TDFs that have more than 50% of their assets invested in index funds.

In this table, observations are at the fund-quarter level. In Columns (1) to (3), the dependent variable $RebalFlow^{FE}_{k,q}$ is calculated as the difference between TDF's total foreign equity trade and flow-driven trade scaled by the lagged total net assets. $ResidRebalFlow^{FE-DE}_{k,q}$ equals the difference between the rebalancing flow and a hypothetical rebalancing flow that reverts 100% of the mechanical changes in weights between the total equity and fixed income holdings. The rebalancing flow variables are winsorized at 1% level. $RebalWeight^{FE}_{k,q}$ is defined as the deviation of the actual foreign equity weight at quarter q from the counterfactual mechanical weight at quarter q if the TDF did not make any trades.. $RebalWeight^{FE-DE}_{k,q}$ is the relative rebalancing weight of foreign equity adjusted within the equity asset class. $Pred.rebal^{FE-DE}_{k,q}$ and $Pred.rebal^{FE-DE}_{k,q-1}$ are the predicted quarterly rebalancing flow to foreign equity from domestic equity or fixed income based on the benchmark return difference and the actual allocation weight at the end of the previous quarter. Benchmark returns $R^{DE}_{Bench,q}$, $R^{FE}_{Bench,q}$ and $R^{FI}_{Bench,q}$ are the value-weighted U.S equity return from Kenneth French website, Vanguard Total International Stock Index Fund return, and Vanguard Total Bond Market Index Fund return. $R^{DE}_{Fund,q}$, $R^{FE}_{Fund,q}$, and $R^{FI}_{Fund,q}$ are value-weighted returns of a TDF's underlying domestic equity, foreign equity, and fixed income mutual funds. Control variables include the lagged quarter's log TDF assets, log series size, cash allocation share, current quarter's TDF flow rate, TDF quarterly return, and years to target retirement year. The specifications include TDF fixed effects. We double-cluster the standard errors by TDF and quarter, and report standard errors in brackets. $^*p < .10$; $^{**}p < .05$; $^{***}p < .01$.

	$RebalFlow^{FE}_{k,q}$			$ResidRebalFlow^{FE-DE}_{k,q}$			$RebalWeight^{FE}_{k,q}$			$RebalWeight^{FE-DE}_{k,q}$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$Pred.rebal^{FE-DE}_{k,q}$	0.634***			0.803***			0.723***			0.967***		
	(0.070)			(0.062)			(0.062)			(0.077)		
$Pred.rebal^{FE-DE}_{k,q-1}$	0.062			0.124			0.283***			0.142		
	(0.129)			(0.086)			(0.078)			(0.086)		
$Pred.rebal^{FE-FI}_{k,q}$	0.851***			0.001			0.600***			-0.044		
	(0.084)			(0.081)			(0.076)			(0.139)		
$Pred.rebal^{FE-FI}_{k,q-1}$	0.038			-0.025			0.011			0.024		
	(0.137)			(0.061)			(0.105)			(0.083)		
$(R^{FE}_{Bench,q} - R^{DE}_{Bench,q})$		-0.058***			-0.095***			-0.069***			-0.125***	
		(0.015)			(0.012)			(0.011)			(0.014)	
$(R^{FE}_{Bench,q-1} - R^{DE}_{Bench,q-1})$		-0.011			-0.017			-0.036***			-0.019	
		(0.020)			(0.012)			(0.013)			(0.014)	
$(R^{FE}_{Bench,q} - R^{FI}_{Bench,,q})$		-0.061***			-0.006			-0.047***			-0.004	
		(0.016)			(0.012)			(0.012)			(0.014)	
$(R^{FE}_{Bench,q-1} - R^{FI}_{Bench,q-1})$		-0.002			0.004			-0.001			0.002	
		(0.008)			(0.005)			(0.005)			(0.005)	
$(R^{FE}_{Fund,q} - R^{DE}_{Fund,q})$			-0.051**			-0.080***			-0.080***			-0.133***
			(0.024)			(0.017)			(0.011)			(0.015)
$(R^{FE}_{Fund,q-1} - R^{DE}_{Fund,q-1})$			-0.019			-0.014			-0.026**			-0.017
			(0.025)			(0.012)			(0.011)			(0.014)
$(R^{FE}_{Fund,q} - R^{FI}_{Fund,q})$			-0.096***			-0.021			-0.035***			-0.002
			(0.030)			(0.016)			(0.012)			(0.014)
$(R^{FE}_{Fund,q-1} - R^{FI}_{Fund,q-1})$			-0.002			0.004			-0.000			0.003
			(0.007)			(0.005)			(0.007)			(0.007)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TDF FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,427	4,427	4,427	4,427	4,427	4,427	4,427	4,427	4,427	4,427	4,427	4,427
Adjusted R^2	0.162	0.112	0.180	0.162	0.136	0.135	0.548	0.521	0.524	0.0872	0.0842	0.100

Table A.2: Active TDF Rebalancing of Foreign Equity

Robustness test of Table 3: We analyze the rebalancing flows and weights of the subsample of active TDFs that have less than 50% of their assets invested in index funds.

In this table, observations are at the fund-quarter level. In Columns (1) to (3), the dependent variable $RebalFlow_{k,q}^{FE}$ is calculated as the difference between TDF's total foreign equity trade and flow-driven trade scaled by the lagged total net assets. $ResidRebalFlow_{k,q}^{FE-DE}$ equals the difference between the rebalancing flow and a hypothetical rebalancing flow that reverts 100% of the mechanical changes in weights between the total equity and fixed income holdings. The rebalancing flow variables are winsorized at 1% level. $RebalWeight_{k,q}^{FE}$ is defined as the deviation of the actual foreign equity weight at quarter q from the counterfactual mechanical weight at quarter q if the TDF did not make any trades.. $RebalWeight_{k,q}^{FE-DE}$ is the relative rebalancing weight of foreign equity adjusted within the equity asset class. $Pred.rebal_{k,q}^{FE-DE}$ and $Pred.rebal_{k,q-1}^{FE-DE}$ are the predicted quarterly rebalancing flow to foreign equity from domestic equity or fixed income based on the benchmark return difference and the actual allocation weight at the end of the previous quarter. Benchmark returns $R_{Bench,q}^{DE}$, $R_{Bench,q}^{FE}$ and $R_{Bench,q}^{FI}$ are the value-weighted U.S equity return from Kenneth French website, Vanguard Total International Stock Index Fund return, and Vanguard Total Bond Market Index Fund return. $R_{Fund,q}^{DE}$, $R_{Fund,q}^{FE}$, and $R_{Fund,q}^{FI}$ are value-weighted returns of a TDF's underlying domestic equity, foreign equity, and fixed income mutual funds. Control variables include the lagged quarter's log TDF assets, log series size, cash allocation share, current quarter's TDF flow rate, TDF quarterly return, and years to target retirement year. The specifications include TDF fixed effects. We double-cluster the standard errors by TDF and quarter, and report standard errors in brackets. $^{*}p < .10$; $^{**}p < .05$; $^{***}p < .01$.

	$RebalFlow_q^{FE}$			$ResidRebalFlow_q^{FE-DE}$			$RebalWeight_q^{FE}$			$RebalWeight_q^{FE-DE}$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$Pred.rebal_q^{FE-DE}$	0.472***			0.507***			0.486***			0.549***		
	(0.086)			(0.062)			(0.089)			(0.077)		
$Pred.rebal_{q-1}^{FE-DE}$	0.108			0.156**			0.101			0.221**		
	(0.120)			(0.075)			(0.097)			(0.091)		
$Pred.rebal_q^{FE-FI}$	0.650***			-0.014			0.057			0.145		
	(0.096)			(0.070)			(0.120)			(0.115)		
$Pred.rebal_{q-1}^{FE-FI}$	0.092			-0.060			0.122			-0.098		
	(0.103)			(0.059)			(0.115)			(0.107)		
$(R_{Bench,q}^{FE} - R_{Bench,q}^{DE})$		-0.057***			-0.066***			-0.064***			-0.062***	
		(0.014)			(0.009)			(0.018)			(0.016)	
$(R_{Bench,q-1}^{FE} - R_{Bench,q-1}^{DE})$		-0.024			-0.027***			-0.023			-0.037**	
		(0.016)			(0.009)			(0.015)			(0.016)	
$(R_{Bench,q}^{FE} - R_{Bench,,q}^{FI})$		-0.038**			0.007			0.001			-0.010	
		(0.015)			(0.010)			(0.018)			(0.015)	
$(R_{Bench,q-1}^{FE} - R_{Bench,q-1}^{FI})$		0.001			0.006			-0.002			0.009	
		(0.006)			(0.005)			(0.007)			(0.006)	
$(R_{Fund,q}^{FE} - R_{Fund,q}^{DE})$			-0.051**			-0.068***			-0.049**			-0.072***
			(0.022)			(0.014)			(0.018)			(0.018)
$(R_{Fund,q-1}^{FE} - R_{Fund,q-1}^{DE})$			-0.001			-0.020*			-0.012			-0.046***
			(0.015)			(0.010)			(0.014)			(0.017)
$(R_{Fund,q}^{FE} - R_{Fund,q}^{FI})$			-0.074**			-0.018			-0.027			-0.034*
			(0.028)			(0.015)			(0.021)			(0.017)
$(R_{Fund,q-1}^{FE} - R_{Fund,q-1}^{FI})$			-0.002			0.006			-0.004			0.011
			(0.008)			(0.005)			(0.008)			(0.007)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TDF FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,786	8,786	8,786	8,786	8,786	8,786	8,786	8,786	8,786	8,786	8,786	8,786
Adjusted R^2	0.112	0.0910	0.119	0.0843	0.0772	0.0970	0.637	0.635	0.636	0.0622	0.0552	0.0760

Table A.3: TDF Ownership and Flow to Foreign Equity Mutual Funds

Robustness test of Table 7: We examine the flows to the subsample of 385 mutual funds that have ever been owned by a TDF instead of analyzing the entire sample of 2,506 U.S. foreign equity mutual funds.

In this table, observations are at the mutual-fund-quarter level. We restrict the sample to U.S. based foreign equity mutual funds that have ever been owned by TDFs from 2011Q1 to 2022Q4. The dependent variable $MFflow_{i,q}$ is the mutual fund flow scaled by the fund's assets under management at the end of the previous quarter. Benchmark returns $R^{DE}_{Bench,q}$, $R^{FE}_{Bench,q}$ and $R^{FI}_{Bench,q}$ are the CRSP value-weighted U.S equity return, Vanguard Total International Stock Index Fund return, and Vanguard Total Bond Market Index Fund return. $R_{i,q}$ is the mutual fund return at quarter q. $\%TDF_{i,q-1}$ is the TDF ownership in mutual fund i. Control variables include the lagged log mutual fund size, lagged log mutual fund family size, current log mutual fund age, current cash allocation share, and current expense ratio. The specifications include mutual fund fixed effects in all specifications as well as quarter time fixed effects in Columns (5) and (6). We double-cluster the standard errors by mutual fund and quarter, and report standard errors in brackets. $^{*}p < .10$; $^{**}p < .05$; $^{***}p < .01$.

	$MFflow_{i,q}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$(R^{FE}_{Bench,q} - R^{DE}_{Bench,q})$	0.113	0.166*				
	(0.080)	(0.087)				
$(R^{FE}_{Bench,q-1} - R^{DE}_{Bench,q-1})$	0.123	0.169				
	(0.098)	(0.109)				
$(R^{FE}_{Bench,q} - R^{DE}_{Bench,q}) \times \%TDF_{i,q-1}$		-0.533***				
		(0.146)				
$(R^{FE}_{Bench,q-1} - R^{DE}_{Bench,q-1}) \times \%TDF_{i,q-1}$		-0.477***				
		(0.165)				
$(R^{FE}_{Bench,q} - R^{FI}_{Bench,q})$			0.014	0.033		
			(0.026)	(0.027)		
$(R^{FE}_{Bench,q-1} - R^{FI}_{Bench,q-1})$			0.128***	0.142***		
			(0.033)	(0.039)		
$(R^{FE}_{Bench,q} - R^{FI}_{Bench,q}) \times \%TDF_{i,q-1}$				-0.180***		
				(0.066)		
$(R^{FE}_{Bench,q-1} - R^{FI}_{Bench,q-1}) \times \%TDF_{i,q-1}$				-0.136*		
				(0.081)		
$R_{i,q}$					0.266***	0.281***
					(0.051)	(0.052)
$R_{i,q-1}$					0.300***	0.315***
					(0.052)	(0.053)
$R_{i,q} \times \%TDF_{i,q-1}$						-0.241***
						(0.076)
$R_{i,q-1} \times \%TDF_{i,q-1}$						-0.205**
						(0.097)
$\%TDF_{i,q-1}$	0.030**	0.010	0.030**	0.032**	0.030**	0.035**
	(0.014)	(0.015)	(0.014)	(0.015)	(0.014)	(0.015)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Mutual Fund FE	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	No	No	No	No	Yes	Yes
Observations	14,173	14,173	14,173	14,173	14,173	14,173
Adjusted R^2	0.168	0.169	0.171	0.172	0.189	0.190

Table A.4: TDF Ownership and Stock Comovement

Robustness test of Table 8: We extend the sample to include all 5,581 foreign stocks that have ever been owned by any U.S. foreign equity mutual fund instead of analyzing only the 4,932 foreign stocks that have ever been owned by TDFs.

In this table, observations are at the foreign-stock-quarter level. The sample includes all foreign stocks that have ever been owned by a U.S. foreign equity mutual fund during the 2011Q1–2022Q4 period. The dependent variables measure the beta of stock returns to the difference in benchmark returns between foreign equities and other asset classes in the TDF portfolio. In Columns (1) and (3), these betas are obtained by estimating the following model $R^{USD}_{s,m} = a_{s,m} + b_{s,m}X_m + \epsilon_{s,m}$ on a stock level using monthly data and 3-years rolling windows. The dependent variables in Columns (2) and (4) are obtained from equation $R^{USD}_{s,m} = a_{s,m} + b'_{s,m}X_m + c_{s,m}X_{m-1} + \epsilon_{s,m}$, estimated also on a stock level using monthly data and 3-years rolling windows. In these specifications, X_m is return difference $(R^{FE}_{Bench,q} - R^{DE}_{Bench,q})$ in Columns (1) and (2), and $(R^{FE}_{Bench,q} - R^{FI}_{Bench,q})$ in Columns (3) and (4). Benchmark returns $R^{DE}_{Bench,q}$, $R^{FE}_{Bench,q}$ and $R^{FI}_{Bench,q}$ are the CRSP value-weighted U.S equity return, Vanguard Total International Stock Index Fund return, and Vanguard Total Bond Market Index Fund return. $\%TDF_{s,q-1}$ is the lagged TDF ownership in stock s in quarter $q-1$. $\%OMF_{s,q-1}$ is the lagged ownership of stock s by other (non-TDF) U.S. foreign equity mutual funds, which enables us to isolate the effect of TDF ownership from other mutual fund investors. Stock-level control variables include the lagged quarter stock return, log of lagged values of market capitalization, turnover, market-to-book ratio, and lagged values of dividend yield, ROE, investment, and illiquidity. Country-level control variables include lagged stock market capitalization, GDP, CPI, interest rate, developed country indicator, local market stock return, and local stock market volatility. Currency-level control variables include the lagged 1-quarter to 4-quarter exchange rate change and exchange rate volatility. The specifications also include the lagged ACWI ex-US index quarterly return and volatility. The specifications include stock fixed effects. We triple-cluster the standard errors by stock, country, and quarter, and report standard errors in brackets. $^*p < .10$; $^{**}p < .05$; $^{***}p < .01$.

	$\hat{b}^{FE-DE}_{s,q}$ (1)	$\hat{b}'^{FE-DE}_{s,q}$ (2)	$\hat{b}^{FE-FI}_{s,q}$ (3)	$\hat{b}'^{FE-FI}_{s,q}$ (4)
$\%TDF_{s,q-1}$	-0.348***	-0.341***	-0.001	-0.001
	(0.077)	(0.079)	(0.071)	(0.072)
$\%OMF_{s,q-1}$	-0.006	-0.006	-0.005	-0.005
	(0.006)	(0.006)	(0.005)	(0.005)
Stock-Level Controls	Yes	Yes	Yes	Yes
Country-Level Controls	Yes	Yes	Yes	Yes
Currency-Level Controls	Yes	Yes	Yes	Yes
ACWI ex US Index Return	Yes	Yes	Yes	Yes
ACWI ex US Index Volatility	Yes	Yes	Yes	Yes
Stock FE	Yes	Yes	Yes	Yes
Observations	141,852	141,852	141,852	141,852
Adjusted R^2	0.284	0.279	0.232	0.230

Table A.5: TDF Rebalancing Flows and Exchange Rates (Country Level)

Robustness test of Table 9: We aggregate the rebalancing flows on a country level.

Observations in this table are at the country-quarter level. Dependent variable $\Delta FX_{c,q}$ is the change of the exchange rate, measured as foreign currency value per US dollar. $RebFlow_{c,q-1}$ is the aggregate rebalancing flow from TDFs to country c in quarter $q-1$ measures in \$ billions. $ResidRebalFlow_{c,q-1}^{FE-DE}$ equals the difference between the rebalancing flow and a hypothetical rebalancing flow that reverts 100% of the mechanical changes in weights between the total equity and fixed income holdings. $RebFlow_{c,q-1}/MV_{c,q-1}$ and $ResidRebalFlow_{c,q-1}^{FE-DE}/MV_{c,q-1}$ are the total rebalancing flow and residual rebalancing flow scaled by total country c market capitalization. $RebFlow_{c,q-1}/TDFMV_{c,q-1}$ and $ResidRebFlow_{c,q-1}^{FE-DE}/TDFMV_{c,q-1}$ are the total rebalancing flow and residual rebalancing flow scaled by the total equity holdings of TDFs in country c. We also control for the lagged TDF and other foreign equity mutual funds ownership shares. Currency-level control variables include the lagged 1-quarter to 4-quarter exchange rate change and exchange rate volatility. Country-level control variables include lagged stock market capitalization, GDP, CPI, interest rate, developed country indicator, local market stock return, and local stock market volatility. The specifications also include the lagged ACWI ex-US index quarterly return and volatility. The specifications include country-fixed effects. We cluster the standard errors by country, and report standard errors in brackets. $^*p < .10$; $^{**}p < .05$; $^{***}p < .01$.

	$\Delta FX_{c,q}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$RebFlow_{c,q-1}$	-1.458**					
	(0.575)					
$ResidRebFlow_{c,q-1}^{FE-DE}$		-2.892**				
		(1.149)				
$RebFlow_{c,q-1}/MV_{c,q-1}$			-20.259***			
			(4.539)			
$ResidRebFlow_{c,q-1}^{FE-DE}/MV_{c,q-1}$				-24.300**		
				(9.923)		
$RebFlow_{c,q-1}/TDFMV_{c,q-1}$					-5.524***	
					(1.696)	
$ResidRebFlow_{c,q-1}^{FE-DE}/TDFMV_{c,q-1}$						-9.520***
						(3.122)
$\%TDF_{c,q-1}$	-3.013***	-2.766***	-2.948***	-2.668**	-3.191***	-3.361***
	(1.026)	(0.998)	(1.025)	(1.000)	(1.017)	(1.004)
$\%OMF_{c,q-1}$	0.326	0.347	0.333	0.340	0.330	0.345
	(0.337)	(0.339)	(0.337)	(0.335)	(0.336)	(0.338)
Country-Level Controls	Yes	Yes	Yes	Yes	Yes	Yes
Currency-Level Controls	Yes	Yes	Yes	Yes	Yes	Yes
ACWI ex US Index Return	Yes	Yes	Yes	Yes	Yes	Yes
ACWI ex US Index Volatility	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,901	1,901	1,901	1,901	1,901	1,901
Adjusted R^2	0.142	0.143	0.143	0.143	0.143	0.145