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Abstract

We quantify the relationships between deep trade liberalization and foreign direct investment (FDI). To this end, we focus on the effects of Deep Trade Agreements (DTAs), and we rely on a structural framework that simultaneously enables us to (i) estimate the direct impact of DTAs on FDI, (ii) translate the partial DTA estimates into general equilibrium effects on FDI; and (iii) obtain partial DTA effects on trade and quantify the impact of DTAs on FDI through trade. We obtain sizable, positive, and statistically significant estimates of the effects of DTAs on both trade and FDI. A counterfactual analysis suggests that, in combination through direct and indirect channels, DTAs have contributed to a large but very asymmetric increase in inward vs. outward FDI.

JEL-Codes: F100, F430, O400.

Keywords: foreign direct investment (FDI), trade liberalization, deep trade agreements.

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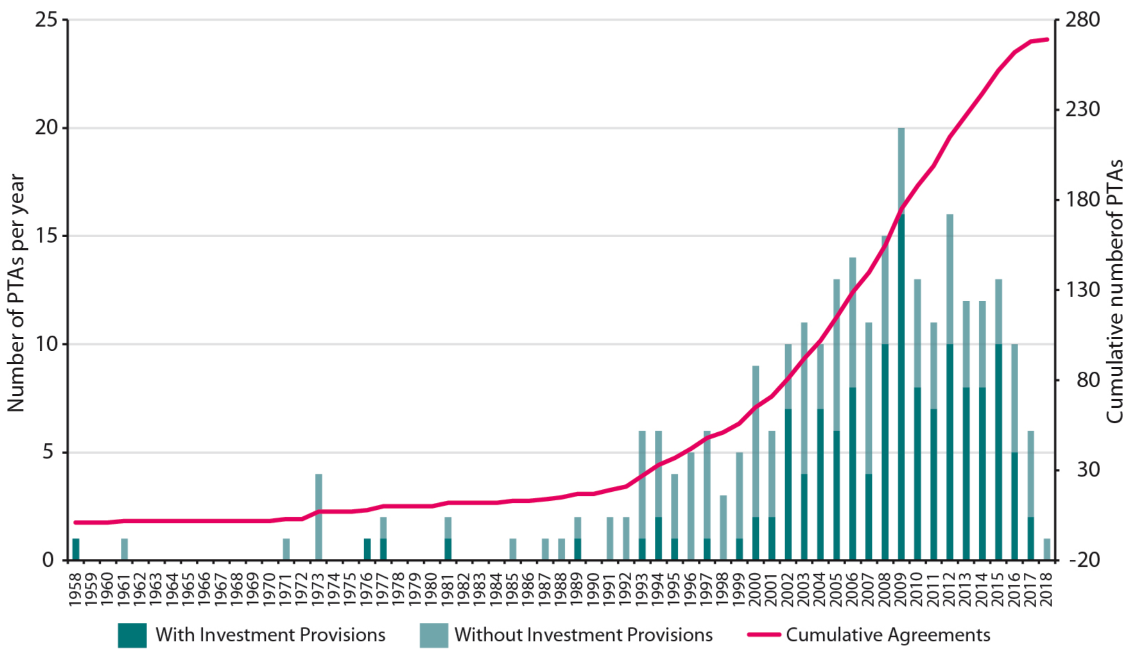
1 Introduction: Motivation and Contributions

Most modern preferential trade agreements (PTAs) include a variety of investment provisions. As pointed out by Crawford and Kotschwar (2020), *"Following the entry into force of NAFTA and the GATS, trade negotiators increasingly began to incorporate into PTAs a broad set of investment provisions that liberalize, protect, and regulate investments."* (p. 145). The increase, both in absolute and in relative terms, in the number of PTAs with investment provisions is depicted in Figure 1, which comes from Crawford and Kotschwar (2020).

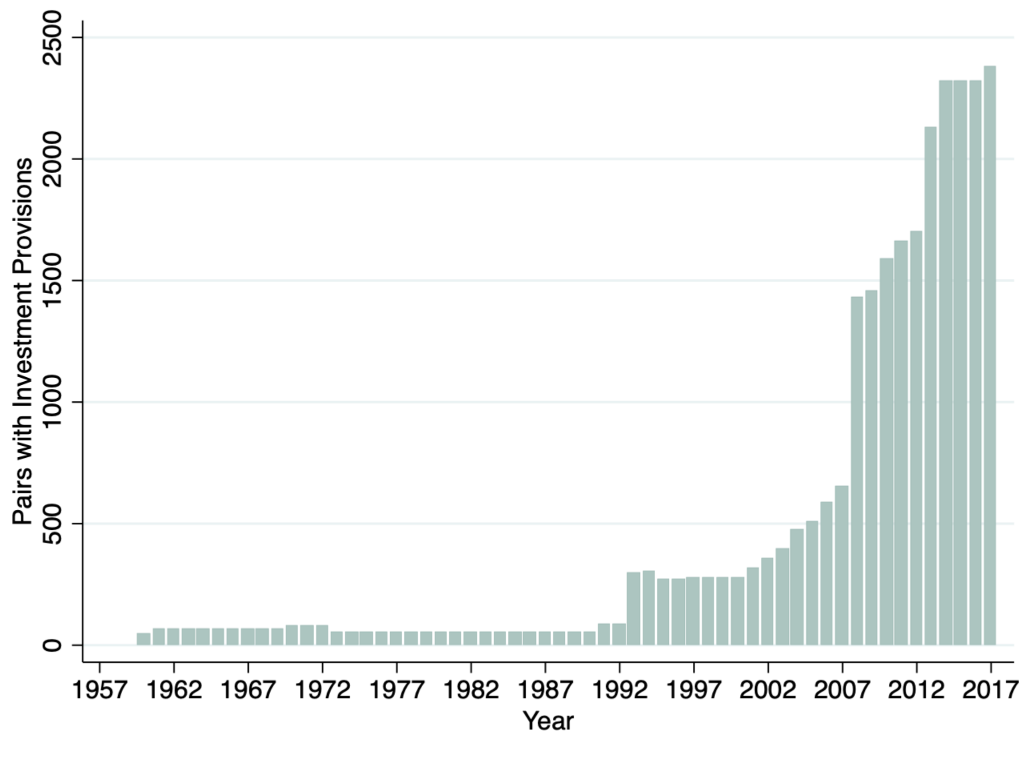
Figure 1: Number of PTAs that include investment provisions, 1958-2018



Notes: This figure plots the number of PTAs with and without investment provisions. The figure comes from Crawford and Kotschwar (2020). The original source is the WTO RTA database: http://rtais.wto.org, May 2018.

Using the World Bank's Database on the Content of Regional Trade Agreements (DCRTA), cf. Hofmann et al. (2019) and Mattoo et al., eds (2020), we complement Figure 1 by plotting the number of country-pairs that have signed a trade agreement that includes investment provisions. Figure 2 clearly corroborates the evidence from Figure 1 by depicting a remarkable increase in the country-pairs that have negotiated investment together with trade, especially since the early 90s as noted in the opening quote from Crawford and Kotschwar (2020).

Figure 2: Country-pairs that have PTAs with Investment Provisions, 1958-2017.



Notes: This figure plots the number of country pairs that have signed a trade agreement that includes investment provisions. The data used to construct the figure is from the World Bank's Database on the Content of Regional Trade Agreements, https://datatopics.worldbank.org/dta/about-the-project.html.

Despite the increase in the number and importance of investment provisions in the negotiations and implementation of PTAs, there is relatively little and mixed evidence on the effectiveness of such provisions in promoting FDI. For example, the authoritative surveys of Eicher et al. (2012) and Blonigen and Piger (2014)[1] on the determinants of FDI do not account for such provisions. Only very recently, some papers (e.g., Kox and Rojas-Romagosa, 2020; Laget et al., 2021) have studied the impact of Deep Trade Agreements (DTAs) and various PTA provisions (disciplines) on FDI, offering mixed evidence on the impact of in-

[1] Other examples of studies on determinants of FDI, including studies on the impact of trade liberalization and deep trade agreements on FDI, include Baltagi et al. (2008), Medvedev (2012), Osnago et al. (n.d.), and Di Ubaldo and Gasiorek (2022).

vestment provisions.[2]

Against this backdrop, we make three contributions to the existing literature on the links between deep trade liberalization and FDI. First, we contribute to the debate on whether deep trade agreements with investment provisions stimulate FDI by estimating the direct/partial equilibrium effects of DTAs and DTAs with investment and other provisions on FDI. Second, we use our partial estimates to obtain novel general equilibrium (GE) estimates of the effects of DTAs on FDI. Third, within the same structural framework, we obtain estimates of the effects of DTAs on trade flows, and we translate those effects into general equilibrium effects of DTAs on FDI through trade liberalization.

Guided by the theoretical model of Anderson et al. (2019),[3] we specify two estimating gravity equations—one for trade and one for FDI, which are (i) consistent with and representative of a large number studies that quantify the impact of various determinants on FDI (e.g., Eicher et al., 2012; Blonigen and Piger, 2014; Kox and Rojas-Romagosa, 2020; Laget et al., 2021), and (ii) capitalize on the latest developments in the trade gravity literature (e.g., Head and Mayer, 2014; Yotov et al., 2016). Specifically, we rely on the Poisson Pseudo-Maximum-Likelihood estimator to account for potential heteroskedasticity in the bilateral trade and FDI data and to take advantage of the information in the zero trade and FDI flows (cf. Santos Silva and Tenreyro, 2006, 2011). In addition, we employ a very rich set of fixed effects (including origin-time, destination-time, and directional country-pair fixed effects), which control for and absorb all possible country-specific and time-invariant bilateral deter-

[2] For example, Lesher and Miroudot (2006) obtain positive effects of investment provisions on FDI, while, more recently, Kox and Rojas-Romagosa (2020) and Laget et al. (2021) do not find that investment provisions have significant additional impact on FDI. Moreover, we are not aware of existing work that quantifies the full/general equilibrium impact of DTAs and their investment provisions on FDI.

[3] The theoretical model of Anderson et al. (2019) suits our objectives well because it (i) offers structural foundations for both our trade and FDI estimating gravity models and (ii) enables us to translate our partial estimates of the effects of DTAs on trade and welfare into GE effects on FDI. Our contributions in relation to Anderson et al. (2019) is twofold. First, from a methodological perspective, they *calibrate* the model in a cross section while we build a panel dataset to *estimate* some of the structural equations in order to test for and establish causality in the relationships of interest to us. Second, from a policy perspective, Anderson et al. (2019) simulate a world without FDI, while our aim is to quantify the impact of deep trade agreements on FDI. In policy work that is not intended for publication, Anderson et al. (2016) rely on the framework of Anderson et al. (2019) to quantify the effects of CETA.

minants of trade and FDI. Thus, mitigating omitted variable bias and endogeneity concerns with the key variables of interest to us. In addition to PTAs and DTAs, we control for other policy variables such as WTO membership, economic sanctions, and bilateral investment treaties.

To perform the empirical analysis we build a balanced panel data set for 89 countries covering more than 96 percent of world GDP and more than 94 percent of FDI throughout the sample period, 1990-2011. Our data set covers foreign direct investment, trade agreements, trade flows, gross domestic product (GDP), employment, physical capital, bilateral investment treaties, sanctions, and WTO membership. An important feature of the dataset is that we capitalize on the richness of the Database on the Content of Regional Trade Agreements (DCRTA), cf. Hofmann et al. (2019) and Mattoo et al., eds (2020). Specifically, the DCRTA enables us to distinguish between several indicator and continuous PTA variables, including a standard dummy variable for PTAs, an indicator variable for DTAs, an indicator for DTAs that include investment provisions, and two continuous variables for the overall depth of DTAs and for the depth of the DTAs with investment provisions.

Three main findings stand out from our estimates of the effects of DTAs on trade. First, we find that the average impact of PTAs in our sample is not statistically significant. However, second, we obtain positive and statistically significant estimates of the effects of deep trade agreements. Specifically, our estimates suggest that the DTAs in our sample have led to a 16.1% (std.err. 3.184) increase in bilateral trade among member counties. Finally, our estimates reveal that deeper trade agreements (as measured by the number of provisions) lead to larger increases in the trade flows among DTA members. Depending on the number of provisions that they include, the DTAs in our sample have led to trade increases between 0.576% (std.err. 0.289) and 23.012% (std.err. 12.744). Overall, our estimates of the DTA effects in trade are consistent with findings from recent studies that have utilized the database on the Content of Regional Trade Agreements and reinforce the view that 'depth' matters for the effectiveness of PTAs.[4]

Similar to our results for trade, the estimates of the effects of DTAs on FDI are also heterogeneous. Specifically, we do not obtain significant estimates of the effects of PTAs and DTAs on FDI. However, when we zoom in on the effects of DTAs that include investment provisions, we obtain a positive, sizable, and statistically significant estimate, which suggests that, on average, the PTAs with investment provisions in our sample have lead to a 34.33% (std.err. 14.535) increase in FDI between their members. This result is consistent with earlier findings from Lesher and Miroudot (2006). We also obtain positive estimates of the effects on FDI of several other DTA provisions including 'labor market regulations', 'export taxes', 'public procurement' and 'state owned enterprises'. This analysis reinforces and complements the findings of Laget et al. (2021) who study the impact of different DTA provisions with firm-level data for the period 2003-2015. Finally, our estimates do not reveal a significant impact of the increase in the depth (number of provisions) on FDI. In fact, our results suggest that an increase in the number/complexity of some investment provisions (e.g., related to 'transparency' and 'regulations') may actually decrease FDI.

We use the structural model in combination with our estimates of the partial effects of DTAs on trade and FDI in order to quantify the GE impact of DTAs on FDI.[5] We focus the analysis on inward usage of technology FDI per country and outward technology FDI stocks per country used abroad. The main conclusions from this analysis are as follows. DTAs have had large and strongly asymmetric effects on FDI. The DTAs that were in force in 2011 have contributed to about 3% of inward FDI in the world and about 70% of outward FDI. The large average effect of outward FDI is driven by some large outward FDI countries (such as USA and China), where, consistent with our theoretical model of non-rival

[4] We refer the reader to Fernandes et al., eds (2021), an eBook from the World Bank and CEPR, which is a collection of excellent papers that focus on various aspects of the determinants of DTAs and on the DTA effects on trade and other economic outcomes.

[5] As discussed in more detail in Section 4.2, a caveat with our GE analysis is that the underlying theory is based on the assumption of non-rival technology FDI, while our data includes all/aggregate FDI flows. While this gap, of course, has implications for the quantitative results, our conclusions about the disproportionately large impact of outward FDI will remain qualitatively the same if applied to better suited data.

capital, any change in the technology stock of these countries has a multiplying effect due to the usage in many other countries, resulting in a large boost in outward FDI stock usage abroad. We view our result about the disproportionately large impact of outward FDI as novel and potentially important from a policy perspective, both for the negotiations of trade and investment agreements and for properly quantifying their implications.

Finally, we also find that changes in trade costs due to DTAs have lead to additional boosts in FDI through the GE links between trade and FDI in our model. Specifically, through their impact on trade costs, the 2011 DTAs in our model have boosted inward FDI by an additional 1 percentage point and outward FDI by 10 additional percentage points, i.e., effects that are about a quarter of the corresponding estimates due to FDI liberalization. By demonstrating that the impact of DTAs on FDI through trade is significant, we complement some recent work on the GE links between DTAs and trade, cf. Fontagne et al. (2021), and also, from a broader perspective, papers that have studied the GE links between trade liberalization and FDI, cf. Baltagi et al. (2008), Tintelnot (2017), and Anderson et al. (2019).

The rest of the paper is organized as follows. Section 2 presents the methodological foundations of our analysis, including the theoretical foundations (in Subsection 2.1), a discussion of the alternative channels through which DTAs impact FDI (in Subsection 2.2), and the specifications of our estimating equations for bilateral trade flows and FDI (in Subsection 2.3). Section 3 describes the main variables and the corresponding data sources that we use to construct them. Section 4 presents and discusses our partial estimates (in Subsection 4.1) and our GE results (in Subsection 4.2). Section 5 concludes and we offer a supplementary Appendix that includes the derivations of the theoretical model.

2 Methods

In order to quantify the impact of deep trade agreements on FDI, we rely on the theoretical framework of Anderson et al. (2019). While, our current contribution is purely empirical, we find it helpful to summarize the model of Anderson et al. (2019). We do this in Section 2.1 for two reasons. First, as demonstrated in Section 2.2, it will enable us to describe and decompose several partial and GE channels through which DTAs impact FDI. In addition, in Section 2.3, we will capitalize on the structural equations for bilateral trade flows and FDI in order to specify the corresponding estimating equations, which in turn will deliver our key estimates of the direct impact of DTAs on trade and FDI.

2.1 Theoretical Foundations

To motivate and perform the empirical analysis, we rely on the theoretical framework of Anderson et al. (2019), who derive a multi-country dynamic model of trade, investment in physical capital and FDI under the following assumptions.[6] Each country ($i, j \in N$) produces a single tradeable good (differentiated by place of origin, Armington, 1969), which, subject to iceberg trade frictions ($t_{ij,t} \geq 1$), can be used for consumption ($C_{j,t}$) and to build country-specific physical capital ($K_{j,t}$) in any other country. In addition, each country invests in non-rival technology capital ($M_{j,t}$),[7] and the technology capital of one country can be used in all other countries subject to investment frictions ($1 \geq \omega_{ij,t} \geq 0$).[8]

The decisions on aggregate consumption ($C_{j,t}$), aggregate investment in physical capital ($\Omega_{j,t}$), and aggregate investment in technology capital ($\chi_{j,t}$) in each country are made by representative agents who maximize the present discounted value of their lifetime utility subject to a sequence of constraints, as captured by the following consumer optimization

[6]We refer the reader to Anderson et al. (2019) for motivation behind some of the assumptions and for details on all derivations. For the convenience of the reader, we enclose the online Appendix from Anderson et al. (2019) along with this paper.

[7]The modeling of FDI in form of non-rival technology capital is in the spirit of Markusen (2002), McGrattan and Prescott (2009, 2010, 2014) and McGrattan and Waddle (2017). One interpretation of technology capital is akin to the notion of knowledge capital, and possible examples include patents, blue-prints, management skills/practices, etc.

[8]If $\omega_{ij,t} = 1$, then country j is totally open to the use of foreign technology of country i capital at time t within its borders. If $\omega_{ij,t} = 0$, no foreign technology from country i can be used in country j at time t.

problem:

$$\max_{\{C_{j,t},\Omega_{j,t},\chi_{j,t}\}} \quad \sum_{t=0}^{\infty} \beta^t \ln(C_{j,t}) \tag{1}$$

$$K_{j,t+1} = (1-\delta_{j,K})\,K_{j,t} + \Omega_{j,t} \quad \text{for all } t, \tag{2}$$

$$M_{j,t+1} = (1-\delta_{j,M})\,M_{j,t} + \chi_{j,t} \quad \text{for all } t, \tag{3}$$

$$Y_{j,t} = p_{j,t}A_{j,t}\left(L_{j,t}^{1-\alpha_j}K_{j,t}^{\alpha_j}\right)^{1-\phi}\left(\prod_{i=1}^{N}(\max\{1,\omega_{ij,t}M_{i,t}\})^{\eta_i}\right)^{\phi} \quad \text{for all } t, \tag{4}$$

$$E_{j,t} = P_{j,t}C_{j,t} + P_{j,t}\Omega_{j,t} + P_{j,t}\chi_{j,t} \quad \text{for all } t, \tag{5}$$

$$E_{j,t} = Y_{j,t} + \phi\eta_j \sum_{i\in\mathbb{N}_{ji,t}} Y_{i,t} - \phi Y_{j,t}\sum_{i\in\mathbb{N}_{ij,t}} \eta_i \quad \text{for all } t, \tag{6}$$

$$K_{j,0}\,,\ M_{j,0} \text{ given.} \tag{7}$$

Equation (1) is the representative agent's intertemporal utility function, where aggregate consumption, $C_{j,t} = \left(\sum_{i=1}^{N}\gamma_i^{\frac{1-\sigma}{\sigma}} c_{ij,t}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$, comprises of domestic and foreign goods ($c_{ij,t}$) from all possible countries. Equation (2) is the transition function for accumulation of physical capital, where $\delta_{j,K}$ is the depreciation rate and $\Omega_{j,t} = \left(\sum_{i=1}^{N}\gamma_i^{\frac{1-\sigma}{\sigma}}\left(I_{ij,t}^{K}\right)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$ denotes the aggregate flow of investment in physical capital in country j at time t as a CES aggregate of investment goods ($I_{ij,t}^{K}$) from all countries.[9] Similarly, equation (3) is the transition function for accumulation of technology capital, where $\delta_{j,M}$ is the depreciation rate and $\chi_{j,t} = \left(\sum_{i=1}^{N}\gamma_i^{\frac{1-\sigma}{\sigma}}\left(I_{ij,t}^{M}\right)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$ denotes the CES-aggregated flow of investments of technology capital ($I_{ij,t}^{M}$) in j at time t from all countries, including j itself.

Equation (4) is the production value function. Here, $p_{j,t}$ denotes the factory-gate price of good (country) j at time t, $A_{j,t}$ is the local, country-specific technology, $L_{j,t}$ is country-specific (internationally immobile) labor, and all other variables are defined earlier. Note that the last term $\left(\prod_{i=1}^{N}(\max\{1,\omega_{ij,t}M_{i,t}\})^{\eta_i}\right)$ is the global technology stock applied locally. When $\omega_{ij,t} = 0$, no foreign technology from country i can be used in country j at time t, and when $\omega_{ij,t} = 1$ usage of foreign technology is frictionless. With $\omega_{ij,t} > 0$ every unit of

[9] The assumption that consumption and investment goods are subject to the same CES aggregation is very convenient analytically. Allowing for heterogeneity in preferences and prices between and within consumption and investment goods requires sectoral treatment and will open additional channels for the interaction between trade liberalization and FDI.

foreign technology from country i at time t has $\omega_{ij,t}$-times the use in country j. By assuming $\sum_{i=1}^{N} \eta_i = 1$, we impose constant returns to scale. The *max*-function implements the notion that there is some world knowledge of technology capital freely available to all countries and ensures that there is always some technology capital available for all countries. Equation (5) gives total expenditure in country j at time t, $E_{j,t}$, as the sum of spending on consumption ($P_{j,t}C_{j,t}$), spending on investment in physical capital ($P_{j,t}\Omega_{j,t}$), and spending on investment in technology capital ($P_{j,t}\chi_{j,t}$). Finally, Equation (6) defines disposable income, which is equal to expenditure, as the sum of total nominal output ($Y_{j,t}$) plus rents from foreign investments $\left(\phi\eta_j \sum_{i\in\mathbb{N}_{ji,t}} Y_{i,t}\right)$, minus rents accruing to foreign investments $\left(\phi Y_{j,t} \sum_{i\in\mathbb{N}_{ij,t}} \eta_i\right)$, where $\mathbb{N}_{ij,t} \equiv \{i \neq j, \omega_{ij,t} M_{i,t} > 1\}$.

Solving the representative agent's problem delivers the following steady state structural system that describes the relationships between trade, domestic investment, and FDI:[10]

$$X_{ij} = \frac{Y_i E_j}{Y}\left(\frac{t_{ij}}{\Pi_i P_j}\right)^{1-\sigma} \quad \text{for all } i \text{ and } j \tag{8}$$

$$P_j^{1-\sigma} = \sum_{i=1}^{N}\left(\frac{t_{ij}}{\Pi_i}\right)^{1-\sigma}\frac{Y_i}{Y} \quad \text{for all } j, \tag{9}$$

$$\Pi_i^{1-\sigma} = \sum_{j=1}^{N}\left(\frac{t_{ij}}{P_j}\right)^{1-\sigma}\frac{E_j}{Y} \quad \text{for all } i, \tag{10}$$

$$p_j = \frac{\left(Y_j / \sum_{j=1}^{N} Y_j\right)^{\frac{1}{1-\sigma}}}{\gamma_j \Pi_j} \quad \text{for all } j, \tag{11}$$

$$Y_j = p_j A_j \left(L_j^{1-\alpha_j} K_j^{\alpha_j}\right)^{1-\phi}\left(\prod_{i=1}^{N}\left(\max\{1, \omega_{ij} M_i\}\right)^{\eta_i}\right)^{\phi} \quad \text{for all } j, \tag{12}$$

$$E_j = Y_j + \phi\eta_j \sum_{i\in\mathbb{N}_{ji,t}} Y_i - \phi Y_j \sum_{i\in\mathbb{N}_{ij,t}} \eta_i \quad \text{for all } j, \tag{13}$$

$$K_j = \frac{\alpha_j \beta (1-\phi)\left(1 - \phi\sum_{i\in\mathbb{N}_{ij,t}} \eta_i\right)}{1 - \beta + \beta\delta_{j,K}}\frac{Y_j}{P_j} \quad \text{for all } j, \tag{14}$$

$$FDI_{ij}^{value} = \Gamma_i \omega_{ij} \frac{E_i}{P_i}\frac{Y_j}{M_i} \quad \text{for all } i \text{ and } j. \tag{15}$$

[10]Mechanically, the model is solved in two stages. First, for given aggregate variables, the demands for $c_{ij,t}$, $I_{ij,t}^{K}$ and $I_{ij,t}^{M}$ are obtained. Then, the dynamic optimization problem for $C_{j,t}$, $\Omega_{j,t}$ and $\chi_{j,t}$ is solved. The focus on the steady state system is consistent with other FDI models, e.g., Head and Ries (2008).

Equations (8)-(11) may look familiar, because they represent the structural gravity trade system of Anderson and van Wincoop (2003). Equation (8) is the standard structural gravity equation. $\Pi_{i,t}^{1-\sigma}$ and $P_{j,t}^{1-\sigma}$ are the multilateral resistance terms (MRTs, outward and inward, respectively), which consistently aggregate bilateral trade costs and decompose their incidence on the producers and the consumers in each region. As defined earlier, equations (12) and (13) define the value of production and the expenditure in country j, respectively.

Equation (14) is the solution for physical capital. Intuitively, the direct relationship between K_j and Y_j reflects the fact that there will be more investment the higher the value of marginal product of physical capital. The inverse relationship between K_j and P_j can be interpreted through the lens of the law of demand, i.e., if P_j is interpreted as the price of investment goods. Alternatively, if P_j is the price of consumption or technology goods, then the intuition for inverse relationship is that there will be less investment when the opportunity cost of it (i.e., investment in consumption or technology goods) is higher.

Finally, equation (15) is the structural gravity equation for FDI, where FDI_{ij} is the value of the stock of FDI from origin i at destination j, $\Gamma_i = \frac{\beta\phi^2\eta_i^2}{1-\beta+\beta\delta_{i,M}}$ is a composite country-specific constant term, and all other variables are defined above. Intuitively, and similar to the gravity model of trade, (15) captures the direct relationship between FDI and the sizes of the source and the destination countries. The explanation for the inverse relationship between FDI and P_j is similar to the relationship between physical capital and P_j. The inverse relationship between FDI and M_i is a reflection of the law of diminishing marginal productivity, i.e., the larger the stock of technology capital in country i, the smaller the marginal productivity by an additional unit of investment in technology. Finally, ω_{ij} denotes the openness measure for foreign technology of country i in country j.[11] The stock of FDI can be defined as:

$$FDI_{ij} \equiv \omega_{ij} M_i. \tag{16}$$

[11] A notable difference between the FDI gravity model (15) and the standard trade gravity model, as captured by(8), is that the FDI gravity equation does not include explicitly an outward multilateral resistance. The intuitive explanation for this is the non-rival nature of technology capital.

For given parameters and variables that are exogenous in the model, i.e., α, β, ϕ, ξ, η_j, γ_j, σ, δ_K, δ_M, $A_{j,t}$, $L_{j,t}$, $t_{ij,t}$, and $\omega_{ij,t}$, we can use system (8)-(15) to simulate the impact of deep trade liberalization on trade and investment in the world. We capitalize on this in Section 4.2. Before that, in Section 2.2, we use (8)-(15) to describe and decompose the partial and GE channels through which DTAs impact FDI. Then, in Section 2.3, we rely on system (8)-(15) to specify the econometric models that will deliver our key estimates of the direct impact of DTAs on trade and FDI.

2.2 On the Links between DTAs and FDI: A Discussion

The objective of this section is to describe and decompose the channels through which DTAs affect FDI. To this end, and consistent with the estimation results that we present in Section 4.1, as comparative static shock to system (8)-(15) we consider the formation of a DTA with investment provisions, which is successful in liberalizing both trade and FDI. For clarity and ease of exposition, we consider a specific hypothetical example—a DTA between the US and the EU. Moreover, consistent with the counterfactual analysis that we perform in Section 4.2, we discuss the effects of trade liberalization and investment liberalization sequentially, starting with the effects of investment liberalization, which is captured by an increase of ω_{ij} in our model. A decrease in FDI barriers will have a direct effect and several indirect (GE) effects on FDI in system (8)-(15).

- *Direct DTAs impact on FDI.* The direct effect of lower bilateral investment costs between EU and US is captured by equation (15), and it would lead to an immediate increase in FDI between the liberalizing partners. In the empirical analysis below, we will be able to identify the direct impact of DTAs on FDI from our estimating FDI gravity model. Then, we will use our partial estimates of these direct effects to simulate the indirect/GE effects, which we describe next.

- *First-order GE effect of DTAs on FDI.* The removal of FDI barriers (i.e, an increase of ω_{ij}) between US and the EU will lead to higher income, through (12), and higher expenditure, through (13), in the two regions. In turn, via equation (15), the changes of the sizes of the liberalizing partners will lead to more FDI between them and also, *ceteris paribus*, between each of them and all other countries in the world. These GE size effects are similar to the familiar size effects from the trade gravity literature.

- *Second-order GE effect of DTAs on FDI.* The changes of the sizes of the two regions will lead to changes in the multilateral resistances through system (9)-(10). This relationship is inverse, which means that the MRs will fall. In turn, a lower inward multilateral resistance will stimulate investment via (15). As discussed earlier, the intuition for this result is that the IMR can be interpreted alternatively as the price of investment or the opportunity cost of investment.

- *Third-order GE effects of DTAs on FDI.* Finally, we label the effects of changes in FDI barriers through variables that are not explicitly included in equation (15) as 'third-order GE effect of DTAs on FDI'. System (8)-(15) captures at least two such effects. The first one is via the outward multilateral resistance. As noted earlier, the OMR does not appear explicitly in (15). Nevertheless, it is linked to the other endogenous variables in our model via the MR system (9)-(10). The second one is via physical capital accumulation, which, as captured by equation (14), would respond to the changes in size and the IMR and, in turn, will stimulate further increase in size.

Next, we turn to the effects of DTAs on FDI through trade liberalization, e.g., a reduction in the bilateral trade costs (t_{ij}) between US and the EU countries in our model. Naturally, all such effects would be indirect and, similar to the analysis of FDI liberalization, we discuss three GE channels through which trade liberalization could impact FDI.

- *First-order GE effect of DTAs on FDI.* A fall in the barriers between US and the EU will lead to lower inward multilateral resistance, via the direct relationship between bilateral trade frictions and the IMR as captured by equation (9). In turn, a lower inward multilateral resistance will stimulate investment via equation (15).

- *Second-order GE effect of DTAs on FDI.* Triggered by trade liberalization the outward multilateral resistances for US and the EU will decrease (via (9)-(10)). In turn, this will lead to higher factory-gate prices (via (11)) and larger sizes (via (12) and (13)) in the US and the EU. As discussed earlier, larger sizes would stimulate FDI (via (15)).

- *Third-order GE effects of DTAs on FDI.* Finally, similar to the impact of FDI liberalization, a fall in trade barriers will trigger 'third-order GE effect of DTAs on FDI', which are channeled via the OMR, through system (9)-(10), and via physical capital accumulation, as captured by equation (14).

In sum, this section demonstrated how our structural system captures and decomposes a series of channels through which DTAs may affect FDI in member and non-member countries. We capitalize on this analysis in Section 4.2, where we simulate the GE effects of DTAs based on our own partial estimates of the effects of DTAs on trade and investment, which we obtain in Section 4.1 based on the econometric models that we specify next.

2.3 From Theory to Empirics

A key objective and contribution of this paper is to test for causal links between DTAs, trade, and FDI. Establishing such links, and obtaining estimates of the corresponding direct/partial effects of DTAs on trade and FDI, would also enable us to translate them into GE effects of trade liberalization on FDI through the structural links that we just described in the previous section. In this section, we rely on system (8)-(15) to specify our estimating equations for trade and FDI. Specifically, as noted earlier, equation (8) is the standard structural gravity equation from the trade literature, while (15) is our theoretical gravity equation for FDI. To estimate both equations, we will capitalize on the latest developments in the empirical trade literature.[12] We start with the estimating equation for bilateral trade flows:

$$X_{ij,t} \quad = \quad \exp\left[\psi_{i,t} + \phi_{j,t} + \mu_{ij} + \mathbf{GRAV\_TRADE_{ij,t}}\alpha + \mathbf{DTA\_TRADE_{ij,t}}\beta\right] + \epsilon_{ij,t}, \quad \forall i,j. \quad (17)$$

Here, $X_{ij,t}$ denotes nominal (cf. Baldwin and Taglioni, 2006) exports from i to j at time t. Consistent with theory, $X_{ij,t}$ includes international and domestic trade flows (cf. Yotov, 2022). Estimating equation (17) includes three sets of fixed effects. $\psi_{i,t}$ and $\phi_{j,t}$ denote exporter-time and importer-time fixed effects, respectively, which will account for the country-size and the multilateral resistance terms (cf. Anderson and van Wincoop, 2003) in equation (8), and also for any other observable or unobservable factors that affect trade flows on the exporter or on the importer side. μ_{ij} denotes a set of pair fixed effects, which will control for all time-invariant bilateral trade costs (cf. Egger and Nigai, 2015) and will mitigate endogeneity concerns with respect to the bilateral policy variables in our setting (cf. Baier and Bergstrand, 2007), including DTAs. Our main results will be obtained with directional pair fixed effects, which allow for asymmetric time-invariant trade costs depending on the direction of trade flows, i.e., from i to j vs. from j to i.

The vector $\mathbf{GRAV\_TRADE_{ij,t}}$ includes a set of time-varying bilateral control variables that control for WTO membership ($WTO_{ij,t}$), economic sanctions ($SANCT_{ij,t}$), and bilateral investment treaties ($BIT_{ij,t}$). In addition, we also include a full set of time-varying border indicators ($\sum_t BRDR_{ij,t}$), which would capture any common globalization trends (e.g., improvements in communication, transportation, communication, etc.). Finally, the vector $\mathbf{DTAS_{ij,t}}$ includes the variables whose estimates would be of central interest to us. Specifically, we will differentiate between the effects of preferential trade agreements ($PTA_{ij,t}$), the effects of deep trade agreements ($DTA_{ij,t}$), and we will allow for the effects of DTAs to vary depending on their depth ($DEPTH_{ij,t}$), which will be measured by the number of provisions that they include.

We estimate equation (17) with the Poisson Pseudo-Maximum-Likelihood (PPML) esti-

[12] Larch and Yotov (2022) survey the empirical gravity literature and synthesize the best practices for gravity estimations.

mator in order to account for the presence of heteroskedasticity in the trade data and to take advantage of the information contained in the zero trade flows, cf. Santos Silva and Tenreyro (2006, 2011). We use three-year interval data, cf. Cheng and Wall (2005) and Egger et al. (2022).[13] Finally, we cluster the standard errors by country pair.

Next, guided by equation (15), we specify our estimating gravity equation for FDI as follows:

$$FDI_{ij,t}^{value} = \exp\left[\psi_{i,t} + \phi_{j,t} + \mu_{ij} + \mathbf{GRAV\_FDI_{ij,t}}\tilde{\alpha} + \mathbf{DTA\_FDI_{ij,t}}\tilde{\beta}\right] + \tilde{\epsilon}_{ij,t}, \quad \forall i \neq j. \quad (18)$$

Here, $FDI_{ij,t}^{value}$ is the value of FDI stock from origin i to destination j at time t. Capitalizing on the developments in the bilateral trade and FDI literatures, and for consistency with our estimating equation for trade flows, we specify our FDI econometric model to be as close as possible to our estimating equation for trade flows given in equation (17). Specifically, we use the same estimator (i.e., PPML), we include the same set of fixed effects (i.e., origin-time fixed effects ($\psi_{i,t}$), destination-time fixed effects ($\phi_{j,t}$), and directional pair fixed effects (μ_{ij})), and we employ the same set of time-varying policy covariates (i.e., indicators for WTO membership ($WTO_{ij,t}$), for bilateral investment treaties ($BIT_{ij,t}$), and for sanctions ($SANCT_{ij,t}$)). Finally, just as in our trade specification, we rely on three-year interval data and we use the same clustering (i.e., by country pair).

Even though, from an econometric perspective, we will use exactly the same set of exporter-time and importer-time fixed effects as in our trade equation, the country-time fixed effects in the FDI model would proxy and account for different variables. Following the existing empirical FDI literature,[14] possible robust determinants of FDI in the country of

[13] Cheng and Wall (2005) note that '[f]ixed-effects estimation is sometimes criticized when applied to data pooled over consecutive years on the grounds that dependent and independent variables cannot fully adjust in a single year's time.' (footnote 8, p. 52). Trefler (2004) also criticizes trade estimations pooled over consecutive years. He uses three-year intervals. Baier and Bergstrand (2007) use 5-year intervals. Olivero and Yotov (2012) provide empirical evidence that gravity estimates obtained with 3-year and 5-year lags are very similar. Most recently, Egger et al. (2022) show that gravity models with three-way fixed effects deliver similar estimates of the common estimates of FTAs.

[14] The two leading empirical FDI studies are Eicher et al. (2012) and Blonigen and Piger (2014). The objective of both studies is to identify a set of robust FDI determinants. Both papers utilize Bayesian Model Averaging and each of them comes up with a set of covariates which vary across the four dimensions that

origin include corporate tax rate, corruption, and bureaucratic red tape, while possible candidates at the destination include level of corruption, internal tensions, corporate tax rate, bureaucratic red tape, quality of institutions, etc. Finally, the pair fixed effects in (18) will absorb and account for bilateral distance, common official language, colonial relationships, which, similar to the trade literature, have been found to be among the most robust FDI determinants by both Eicher et al. (2012) and Blonigen and Piger (2014).

There are two differences between equations (17) and (18). First, we cannot include the set of time-varying border effects ($\sum_t BRDR_{ij,t}$) in equation (18) since we only use data on international transactions. This is why we use different notation for the vector of time-varying gravity covariates ($\mathbf{GRAV\_FDI_{ij,t}}$). We also allow for potential differences in the estimated impact of the common policy covariates by denoting the vector of their estimates $\tilde{\alpha}$. Second, and more important for our purposes, we use a different set of variables to capture the impact of DTAs on FDI in vector $\mathbf{DTA\_FDI_{ij,t}}$. Specifically, in addition to including indicators for PTAs ($PTA_{ij,t}$) and DTAs ($DTA_{ij,t}$), we add two more covariates. First, motivated by Osnago et al. (n.d.), Crawford and Kotschwar (2020), and Laget et al. (2021), we include a separate indicator variable ($INV_{ij,t}$) that takes a value of one for agreements that include investment provisions. Second, we also account for depth of the investment treaties by using a count variable ($INV\_DEPTH_{ij,t}$) for the number of investment provisions within the agreements with investment provisions, i.e., similar to the relationship between $PTA_{ij,t}$ and $DEPTH_{ij,t}$ on the trade side, $INV\_DEPTH_{ij,t}$ is a continuous variable that is equal to zero when $INV_{ij,t}$ is zero.[15]

Estimating equations (17) and (18) will deliver the estimates of the effects of DTAs on trade and investment that we will describe in Section 4.1 and use to obtain GE results in

we propose to capture in our study.

[15]The inclusion of trade agreement variables in our FDI gravity model is consistent with Eicher et al. (2012) and Blonigen and Piger (2014) who find that regional trade agreements are among the most important time-varying bilateral determinants of FDI flows. Interestingly, however, neither Eicher et al. (2012) nor Blonigen and Piger (2014) distinguish between the average effects of RTAs and the effects of RTAs covering FDI. As demonstrated by Crawford and Kotschwar (2020) and Laget et al. (2021), FDI chapters and provisions are an important part of contemporary integration efforts. We will provide evidence that such provisions are indeed a very important determinant of FDI.

Section 4.2. Before that, we describe our data.

3 Data and Sources

To perform the empirical analysis we build a balanced panel data set for 89 countries over the period 1990-2011, covering more than 96 percent of world GDP and for more than 94 percent of FDI throughout the sample period.[16] Our data set includes the following variables: foreign direct investment, trade agreements, trade flows, gross domestic product (GDP), employment, physical capital, bilateral investment treaties, sanctions, and WTO membership. We describe the sources to obtain these variables, as well as their construction, in turn next.

- **FDI Data.** We use two sources to construct the FDI variable, ($FDI_{ij,t}$), which takes a central stage in our analysis. The main source for FDI data is the Bilateral FDI Statistics database of the United Nations Conference on Trade and Development (UNCTAD). These data can be accessed at http://unctad.org/en/Pages/DIAE/FDI%20Statistics/FDI-Statistics-Bilateral.aspx. UNCTAD's FDI data covers inflows, outflows, inward stock, and outward stock for 206 countries over the period 1990-2011. Data are collected from national sources and international organizations and to ensure maximum coverage the data are mirrored. The second source of FDI data is the International Direct Investment Statistics database, which is constructed and maintained by the Organization for Economic Co-operation and Development (OECD). OECD's data offers detailed statistics for inward and outward foreign direct investment flows and positions (stocks) of the OECD countries, including transactions between the OECD members and non-member countries. We use the OECD data to ensure consistency and maximum coverage. Finally, we note that, given our theory, we focus our analysis on FDI stocks (positions), which is also the FDI category for which most data are available.[17]

[16] The list of countries and their respective alpha ISO3 codes appear in the first two columns of Table 5.

[17] Anderson et al. (2019) utilize the same sources to construct a cross-section FDI dataset. For the es-

- **Trada Agreements Data.** To account for the presence and depth of trade agreements, we use the World Bank's database on deep trade agreements (DTA), cf. Hofmann et al. (2019) and Mattoo et al., eds (2020), (https://datatopics.worldbank.org/dta/about-the-project.html).[18] Capitalizing on the rich dimensionality of the DTA database, we construct and utilize several variables for our analysis. $PTA_{ij,t}$ is an indicator variable for the presence of any trade agreement between i and j at time t. $DTA_{ij,t}$ is an indicator denoting the presence of a deep agreement between i and j at time t. $DEPTH_{ij,t}$ is a count variable for the number of provisions in the corresponding DTA between i and j. $INV_{ij,t}$ is an indicator variable that takes a value of one if the DTA between i and j includes investment provisions. Finally, $INV\_DEPTH_{ij,t}$ is a count variable for the number of investment provisions in the corresponding DTA between i and j. For further details on the general features of the DTA database we refer the reader to Hofmann et al. (2019) and Mattoo et al., eds (2020). In addition, for analysis with specific focus the investment provisions in the DTAs, we refer the reader to Crawford and Kotschwar (2020).

- **Production Data.** Data on GDP, employment, and capital stocks are from the Penn World Tables 8.0, cf. Feenstra et al. (2013) (http://www.rug.nl/research/ggdc/data/pwt/). For data on GDP, we employ *Output-side real GDP at current PPPs* ($CGDP^o$), which compares relative productive capacity across countries at a single point in time, as the initial level in our counterfactual experiments, and we use *Real GDP using national-accounts growth rates* ($CGDP^{na}$) for our income-based cross-country growth regressions. We measure employment in effective units by multiplying the *Number of persons engaged in the labor force* with the *Human capital index*, which is based on average years of schooling. Finally, capital stocks in the Penn World Tables 8.0

timation analysis in this paper, we also utilize the time variation in the FDI data. In the counterfactual experiments, we rely on the methods of Anderson et al. (2019) to calibrate some parameters and vectors. See Section 4.2 for further details.

[18] Specifically, we used the DTA 2. Database: Information by Trade agreements. Bilateral observations.

are constructed based on accumulating and depreciating past investments using the perpetual inventory method.

- **Trade Data.** Data on international trade flows come from the United Nations Statistical Division (UNSD) Commodity Trade Statistics Database (COMTRADE). We complement the international trade flows data with data on domestic trade flows from Anderson et al. (2020), which we use both for the estimation and for the counterfactual analysis. Anderson et al. (2020) construct domestic trade flows at the aggregate level in two steps. First, they use the ratio between aggregate manufacturing in gross values and total exports of manufacturing goods to construct a multiplier at the country-time level. (Data on gross manufacturing production, which came from the United Nations' IndStat database.) Then, they use this multiplier along with data on aggregate exports to project the values for domestic sales. Availability of data on domestic trade flows predetermined the time coverage of our estimating sample.

- **Other Data.** Finally, in the estimation analysis we employ the following additional covariates as control variables. We control for the presence of bilateral investment treaties with an indicator variable $BIT_{ij,t}$, which comes from the UNCTAD 's data on international investment agreements (IIAs), which can be found at http://investmentpolicyhub.unctad.org/IIA. Data on sanctions come from the Global Sanctions Database (GSDB), cf. Felbermayr et al. (2020) and Kirilakha et al. (2021) (http://www.rug.nl/research/ggdc/data/pwt/). We use the GSDB to include and indicator variable ($SANCT_{ij,t}$) for the presence of sanctions in our estimations. Finally, data on WTO membership, captured by an indicator variable $WTO_{ij,t}$ in our analysis, come from the Dynamic Gravity Dataset (DGD) of the U.S. International Trade Commission, cf. Gurevich and Herman (2018) (http://www.rug.nl/research/ggdc/data/pwt/).

4 Empirical Findings and Analysis

Subsection 4.1 presents our partial estimates of the impact of DTAs on trade and FDI. Then, in Subsection 4.2, we translate the partial estimates into corresponding GE effects, and we analyze the total impact of DTAs on FDI within our framework.

4.1 Estimation Results

Our estimates of the effects of DTAs on trade are presented in Table 1. As discussed earlier, all estimates are obtained with the PPML estimator with three-way fixed effects, including exporter-time, importer-time, and directional country-pair fixed effects. In addition, all specifications use time-varying border dummy variables to control for the presence of common globalization trends, and indicator variables for WTO membership ($WTO_{ij,t}$), bilateral investment treaties ($BIT_{ij,t}$), and economic sanctions ($SANCT_{ij,t}$). In order to highlight the importance of DTAs and their provisions, we develop the estimation analysis in three steps, depending on the definition of the indicator variables designed to capture the impact of trade agreements.

The estimates in column (1) include a single indicator variable, $PTA_{ij,t}$, that reflects the presence of a trade agreement of any type (e.g., deep or shallow) between i and j at time t. Several findings stand out from column (1). Most important for our purposes, we note that, while positive, the estimate on $PTA_{ij,t}$ is economically small and it is not statistically significant. A possible explanation for this result is that we impose a common effect for all trade agreements in our sample, regardless of their type and depth. We demonstrate that this is indeed the case in column (2) of Table 1. Before that, however, we briefly discuss the estimates of the other policy covariates in our specification.

First, we note that the estimate of the impact of WTO is positive, large, and statistically significant. This result is at odds with some of the existing literature, e.g., Rose (2004) and Esteve-Pérez et al. (2020) who find that WTO membership did not promote international

Table 1: Estimates of the Effects of DTAs on Trade

	(1) PTA	(2) DTA	(3) DEPTH
$PTA_{ij,t}$	0.083	-0.051	-0.069
	(0.057)	(0.059)	(0.055)
$DTA_{ij,t}$		0.148	0.047
		(0.028)**	(0.059)
$DEPTH_{ij,t}$			0.000
			(0.000)*
$WTO_{ij,t}$	0.516	0.526	0.538
	(0.044)**	(0.044)**	(0.043)**
$BIT_{ij,t}$	0.281	0.288	0.289
	(0.099)**	(0.098)**	(0.097)**
$SANCT_{ij,t}$	0.031	0.028	0.022
	(0.024)	(0.023)	(0.022)
N	58,323	58,323	58,323

Notes: This table reports estimates of the effects of trade agreements on trade flows over the period 1990-2011. The dependent variable is nominal trade flows. The estimator is PPML. All estimates are obtained with three-year interval data and three-way fixed effects, including exporter-time, importer-time, and directional pair fixed effects. In addition, all specifications include a full set of time-varying border variables. The estimates of the border dummies and all fixed effects, including the constant, are omitted for brevity. The standard errors in all specifications are clustered by country pair. The difference between the three columns are in the set of trade agreement variables. Specifically, column (1) reports the average PTA effect across all agreements in the sample. Column (2) adds the effects of DTAs. Finally, in addition to PTAs and DTAs, column (3) introduces a continuous variable for DTA depth. The estimate on $DEPTH_{ij,t}$ in column (3) is 0.00047. See text for further details.

trade, however, our estimate on $WTO_{ij,t}$ confirms the findings of Larch et al. (2019) for positive WTO effects when domestic trade flows are used to estimate gravity equations. In robustness analysis, which are available upon request, we confirm that when the model is estimated without domestic trade flows, the estimate of the effects of WTO is smaller and it is not statistically significant.

Second, we obtain a positive, sizable, and statistically significant estimate of the impact of bilateral investment treaties (BITs) on trade flows. A possible explanation for this result is multinational production. Third, we do not obtain a significant estimate of the impact of economic sanctions on trade. This result is consistent with estimates from Felbermayr et al. (2020), who argue that average estimates of the effects of sanctions may mask significant heterogeneity across the effects of sanctions by type. In addition, Kirilakha et al. (2021) demonstrate that the relative importance of trade sanctions has fallen significantly over time. In robustness analysis, we allowed for differential effects of different types of sanctions. This did not affect our main findings and conclusions.

Finally, the estimates of the time-varying border variables from our specifications, which we visualize in Figure 3, reveal significant globalization effects during the period 1990-2011. Due to the use of pair fixed effects, we need to drop one border variable, and we selected the border in 1990 as the baseline. Thus, all other other border estimates are obtained as deviations from 1990 and should be interpreted accordingly, i.e., the positive and increasing estimates in Figure 3 capture the positive effects of globalization (smaller impact of borders) on international trade. The dip in 2002 is probably a reflection of the economic recession during this period, while, due to the use of three-year intervals, the deep global economic recession of 2009 is not captured in our graph.

In column (2) of Table 1 we allow for heterogeneous effects between shallow vs. deep trade agreements. To this end, we capitalize on the data from World Bank's DCRTA, cf. Hofmann et al. (2019) and Mattoo et al., eds (2020), to define $DTA_{ij,t}$ as an indicator that takes a value of one for deep trade agreements (i.e., we use the variable 'pta_mapped'

Figure 3: Common Globalization Effects, 1990-2011.

Notes: This figure reports estimates of the impact of globalization on aggregate trade, 1990-2011. These indexes are obtained as the estimates on the time-varying border variables that we include in equation (17). All estimates in the figure are statistically significant at any conventional level. See text for further details.

from the DCRTA database), and it is equal to zero otherwise. Thus, by construction, the observations that take a value of one in the $DTA_{ij,t}$ variable are a subset of the observations that are equal to one in the $PTA_{ij,t}$ dummy from column (1). The main finding from column (2) of Table 1 is encouraging and expected. Specifically, we obtain a positive and statistically significant estimate on $DTA_{ij,t}$, which suggests that, on average, the deep trade agreements in our sample have lead to a 16.1% (std.err. 3.184) increase in bilateral trade among member counties. This result is consistent with and reinforces the general message from Fernandes et al., eds (2021) that DTAs have been effective in stimulating international trade.

Finally, in column (3) of Table 1, we use the DTA database to construct a continuous variable ($DEPTH_{ij,t}$), which counts the number of provisions within each of the DTAs in our sample. The number of provisions across the DTAs in our sample vary between 12 and 432. The main result from column (3) is that, on average, the deeper the agreement, the more it would promote trade among its members. Specifically, we obtain a positive and statistically significant estimate on $DEPTH_{ij,t}$ (0.00047, std.err. 0.00023), which is consistent with the findings from Osnago et al. (n.d.). Our estimate suggests that, depending on the number of provisions that they include, the DTAs in our sample have led to trade increases between 0.576% (std.err. 0.289) and 23.012% (std.err. 12.744). We capitalize on this variation in Section 4.2, where we obtain corresponding GE effects on FDI.

Our estimates of the effects of DTAs on FDI are presented in Table 2. As discussed earlier, and similar to our trade specification, all estimates are obtained with the PPML estimator with three-way fixed effects, including origin-time, destination-time, and directional pair fixed effects. In addition, all specifications include indicator variables for WTO membership ($WTO_{ij,t}$), bilateral investment treaties ($BIT_{ij,t}$), and economic sanctions ($SANCT_{ij,t}$). Similar to our approach with trade flows, in order to highlight the importance of DTAs and their provisions for FDI, we develop the estimation analysis sequentially, in four steps.

The estimates in column (1) of Table 2 include a single indicator variable, $PTA_{ij,t}$, that reflects the presence of a trade agreement of any type (e.g., deep or shallow) between i and j

Table 2: Estimates of the Effects of DTAs on FDI

	(1) PTA	(2) DTA	(3) INV	(4) DEPTH
$PTA_{ij,t}$	-0.029	-0.100	-0.162	-0.134
	(0.072)	(0.102)	(0.101)	(0.100)
$DTA_{ij,t}$		0.072	-0.089	-0.120
		(0.075)	(0.084)	(0.083)
$INV_{ij,t}$			0.295	0.582
			(0.108)**	(0.251)*
$INV\_DEPTH_{ij,t}$				-0.010
				(0.009)
$BIT_{ij,t}$	0.017	0.017	0.023	0.028
	(0.104)	(0.104)	(0.107)	(0.108)
$SANCT_{ij,t}$	-0.019	-0.017	-0.012	-0.012
	(0.049)	(0.048)	(0.048)	(0.048)
$WTO_{ij,t}$	0.465	0.476	0.469	0.463
	(0.356)	(0.353)	(0.359)	(0.363)
N	18,158	18,158	18,158	18,158

Notes: This table reports estimates of the effects of trade agreements on FDI over the period 1990-2011. The dependent variable is the value of FDI stock. The estimator is PPML. All estimates are obtained with three-year interval data and three-way fixed effects, including origin-time, destination-time, and directional pair fixed effects. The estimates of all fixed effects, including the constant, are omitted for brevity. The standard errors in all specifications are clustered by country pair. The difference between the three columns are in the set of trade agreement variables. Specifically, column (1) reports the average PTA effect across all agreements in the sample. Column (2) adds the effects of DTAs. Column (3) isolates the DTAs with investment provisions. Finally, in addition to PTAs, DTAs, and DTAs with investment provisions, column (4) introduces a continuous variable for investment depth. See text for further details.

at time t. The main result from column (1) is that none of the effects of the policy variables in our model, including the impact of trade agreements and BITs, are statistically significant. A possible explanation for this result is that some of the most significant determinants of FDI are country-specific variables on the origin and/or on the destination side (e.g., corporate tax rate, corruption, bureaucratic red tape, quality of institutions, etc.). However, such determinants are fully controlled for and absorbed by the origin-time and the destination-time fixed effects in our specification. Moreover, it is also possible (cf. Eicher et al., 2012; Blonigen and Piger, 2014) that a number of time invariant characteristics (e.g., bilateral distance, common official language, etc.) are important for FDI. However, similar to the country-specific variables, these effects are also absorbed in our econometric model (by the pair fixed effects). Our finding on the insignificant impact of BITs may seem particularly strange, however, this result is common in the related literature, cf. Lesher and Miroudot (2006) and Laget et al. (2021).

Next, in column (2) of Table 2 we allow for heterogeneous effects between shallow vs. deep trade agreements by using the same DTA variable which we constructed for our trade regressions. Even though the estimate on $DTA_{ij,t}$ is positive, it is economically small and not statistically significant. Thus, unlike their significant impact on trade, our estimates suggest that DTAs per se do not promote FDI.

Motivated by Crawford and Kotschwar (2020) and Laget et al. (2021), in our next specification (in column (3) of Table 2), we isolate the effects of DTAs that include investment provisions. To this end, we again rely on the World Bank's DCRTA, cf. Hofmann et al. (2019) and Mattoo et al., eds (2020), which includes 66 possible investment provisions. Based on this information, we construct a dummy variable, $INV_{ij,t}$, which takes a value of one if an agreement includes at least one investment provision, and it is equal to zero otherwise. Thus, by construction, the observations that take a value of one in the $INV_{ij,t}$ indicator are a subset of the observations that are equal to one in the $DTA_{ij,t}$ dummy from column (2).

The main finding from column (3) is that we obtain a positive, sizable, and statistically significant estimate on $INV_{ij,t}$, which suggests that, on average, the PTAs with investment provisions in our sample have lead to a 34.33% (std.err 14.535) increase in FDI between their members. This result complements the findings from Laget et al. (2021), who use firm level data for the period 2003-2015 and obtain positive estimates of the effects of provisions related to 'intellectual property rights' and 'visa and asylum', which vary between 32 and 50 percent, but do not find significant effects of investment provisions on FDI.

Finally, in column (4) of Table 2 we use the DTA database to construct a continuous variable ($INV\_DEPTH_{ij,t}$), which counts the number of investment provisions within each of the DTAs in our sample. The number of investment provisions across the DTAs in our sample vary between 7 and 41. The estimates from column (4) do not reveal a significant impact of the increase in the depth (number of provisions) on FDI. In fact, and pushing inference to the limit, our estimates suggest that the impact of additional provisions is actually negative. A possible interpretation of this result is that more investment provisions make the agreements more difficult to comply with. Despite the fact that our estimate on $INV\_DEPTH_{ij,t}$ is insignificant, we use it in combination with the positive estimates on $INV_{ij,t}$ to construct a continuous FDI response to the impact of DTAs. The resulting effects are all positive and vary between 16.4% (std.err. 19.06) and 66.41% (std.err. 32.99), depending on the number of investment provisions.[19]

We conclude the econometric analysis with two additional sets of experiments that further capitalize on the richness of the DCRTA dataset to shed light on the links between DTA provisions and FDI.[20] First, we complement the analysis of Laget et al. (2021), who study the impact of several alternative PTA disciplines/provisions on FDI, by investigating the effects of all provision types from DCRTA on aggregate FDI. To this end, we rely on the dummy-variable specification from column (3) of Table 2 by sequentially replacing the

[19]Specifically, to obtain these bounds, we used the expression $(\exp(\hat{\beta}_{INV_{ij,t}} + \hat{\beta}_{INV\_DEPTH_{ij,t}} \times N_{min,max}) - 1) \times 100$, where $\hat{\beta}_{INV_{ij,t}}$ and $\hat{\beta}_{INV\_DEPTH_{ij,t}}$ are the corresponding estimates from column (4) of Table 2), and $N_{min,max}$ denotes the minimum (7) and the maximum (42) number of investment provisions in our sample.

[20]We are very grateful to Nadia Rocha and Vanessa Alviarez for suggesting to investigate the effects of additional provisions and alternative measures of the depth of DTAs.

dummy variable for DTAs with investment provisions ($INV_{ij,t}$) with corresponding indicator variables for each of the other seventeen types of provisions from DCRTA. For brevity, in Table 3 we just summarize our main findings with respect to the DTA provisions.

Table 3: Estimates of the Effects of Alternative DTA Provisions on FDI

(1) Provision Description	(2) Estimate	(3) Standard Error
Investment	0.295	0.108
Labor Market Regulations	0.298	0.103
Export Taxes	0.273	0.164
Public Procurement	0.542	0.135
State-Owned Enterprises	0.364	0.134
Movement of Capital	0.182	0.117
Environmental Laws	-0.221	0.239
Intellectual Property Rights	-0.054	0.124
Visa and Asylum	0.121	0.113
Rules of Origin	0.116	0.147
Services	0.084	0.102
Technical Barriers to Trade	0.034	0.109
Subsidies	-0.278	0.235
Sanitary and Phytosanitary	-0.063	0.122
Trade Facilitation and Customs	-0.246	0.187
Anti-dumping Duties	.	.
Countervailing Duties	.	.
Competition Policy	.	.

Notes: This table reports estimates of the effects of a series of DTA provisions on FDI over the period 1990-2011. Each row corresponds to a separate econometric model based on the specification from column (3) of Table 2 after replacing the dummy variable for DTAs with investment provisions ($INV_{ij,t}$) with corresponding indicator variables for each of the other seventeen types of provisions from DCRTA. The dependent variable is the value of FDI stock. The estimator is PPML. All estimates are obtained with three-year interval data and three-way fixed effects, including origin-time, destination-time, directional pair fixed effects, and all other control variables from column (3) of Table 2. The estimates of all fixed effects and controls are omitted for brevity. The standard errors in all specifications are clustered by country pair. See text for further details.

The following results stand out from our analysis. First, due to (near) perfect collinearity with the DTAs dummy, we could not identify the effects of agreements with provisions covering 'antidumping duties', 'countervailing duties', and 'competition policy'. Our indicator for agreements including 'competition policy' provisions is perfectly collinear with the DTA dummy, while the correlations between the indicators for agreements with provisions covering ‘antidumping duties’ and ‘countervailing duties’ and the DTA dummy were larger than 0.99. This is why these three types of provisions appear in the bottom panel of Table 3 without corresponding estimates.

Second, we obtain positive and statistically significant estimates for four additional provisions, which, together with our estimate for investment provisions, are reported in the top panel of Table 3. Consistent with the result from Laget et al. (2021) for FDI in service-related activities, we find that ‘labor market regulations’ promote overall FDI. In addition, we obtain a positive effect of provisions related to ‘export taxes’. We find this result intuitive as well. Finally, we obtain large, positive, and statistically significant estimates of the effects of agreements with provisions that cover ‘public procurement’ and ‘state owned enterprises’. A possible explanation for this result is that such provisions ensure transparency and protection from the host state. We are not aware of existing estimates that link ‘public procurement’ and ‘state owned enterprises’ to FDI and, given the size and significance of our estimates, we view this as an interesting and important channel that deserves a more detailed analysis and investigation.

Finally, we do not find evidence that other provisions, some of which potentially closely related to capital and technology movement, have had a significant impact on FDI. Specifically, our estimates of the effects of provisions related to ‘intellectual property rights’ and ‘movement of capital’ are not statistically significant. Consistent with Laget et al. (2021), our estimate of the effects of ‘movement of capital’ is sizable and positive, but it is not statistically significant in our case. Also similar to Laget et al. (2021), we obtain a negative estimate of the effects of provisions related to ‘environmental laws’, but, again, our estimate is not statistically significant. A possible explanation for the lack of significance is that the correlation between the indicators for DTAs and agreements with environmental provisions is large, i.e., 0.724. Overall, the estimates in Table 3 indicate that, on average, only a few types of DTA provisions affected FDI directly.

In our next experiment, we zoom in on the effects of alternative sets of provisions within the broad category of 'investment' provisions. Specifically, the DCRTA distinguishes between six types of investment provisions, which are listed in the first column of Table 4. As before, we start with a dummy-variables specification, as in column (3) of Table 2, by sequentially replacing the dummy variable for DTAs with investment provisions ($INV_{ij,t}$) with corresponding indicator variables for each of the six types of investment provisions from DCRTA. Our results appear in panel A of Table 4, and we see that they are all positive and significant. In fact, some of the new estimates are identical to our estimate for the overall impact of DTAs with investment provisions. The simple, mechanical explanation for this result is that some of the subcategories of investment provisions (e.g., for 'protection' and 'liberalization') appear in all DTAs that cover investment. Thus, the indicator variables for such provisions are perfectly collinear with our main dummy variable ($INV_{ij,t}$) from column (3) of Table 2. We do, however, obtain positive estimates for some provision types (e.g., covering 'transparency') that are not perfectly collinear with $INV_{ij,t}$.

Table 4: Estimates of the Effects of Alternative Investment Provisions on FDI

	A. Indicator		B. Depth			
Provision Description	Est.	Std.Err.	Est.	Std.Err.	Est.	Std.Err.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Protection	0.295	0.108	0.378	0.169	-0.007	0.013
Liberalization	0.295	0.108	0.264	0.273	0.007	0.056
Transparency	0.185	0.108	0.461	0.164	-0.141	0.064
Regulation	0.289	0.108	0.532	0.159	-0.128	0.055
Dispute Settlement	0.297	0.108	0.553	0.298	-0.095	0.100
Scope and Definitons	0.295	0.108	0.287	0.392	0.002	0.072

Notes: This table reports estimates of the effects of a series of DTA investment provisions on FDI over the period 1990-2011. Each row in each panel corresponds to a separate econometric model. The results in panel A are based on the specification from column (3) of Table 2 after replacing the dummy variable for DTAs with investment provisions ($INV_{ij,t}$) with corresponding indicator variables for each of the six types of investment provisions from DCRTA. The results in panel B are based on the specification from column (4) of Table 2, where we also allow for differential effects depending on the number of investment provisions ('depth') within each type. The dependent variable is always the value of FDI stock. The estimator is PPML. All estimates are obtained with three-year interval data and three-way fixed effects, including origin-time, destination-time, directional pair fixed effects, and all other control variables from columns (3) and (4) of Table 2, respectively. The estimates of all fixed effects and controls are omitted for brevity. The standard errors in all specifications are clustered by country pair. See text for further details.

Since, due to perfect or near-perfect collinearity, we could not obtain informative estimates of the effects of all types of investment provisions with an indicator-variable approach, we also allow for additional and differential effects of such provisions depending on their depth. Specifically, in panel B of Table 4 we rely on the specification from column (4) of Table 2 by sequentially replacing the dummy variables for DTAs with investment provisions ($INV_{ij,t}$) and their depth ($INV\_DEPTH_{ij,t}$) with the corresponding indicator and continuous variables, respectively, for each of the six types of investment provisions. The main message from panel B of Table 4 is consistent with our previous result for no significant impact of the increase in the depth (number of investment provisions) on FDI. In fact, our estimates of the effect of 'depth' for some provision types (e.g., 'transparency' and 'regulation') are negative and statistically significant, suggesting that more investment provisions and additional complexity may make the agreements more difficult to comply with.

In sum, the analysis in this section demonstrated that while trade agreements do not necessarily promote trade and FDI on average, the impact of deep trade agreements on trade and the impact of deep trade agreements that include investment provisions on FDI are positive and statistically significant. In addition to 'investment' provisions, we identified several other types of DTA provisions that have stimulated FDI. We also offered evidence that deeper trade agreements (as measured by the number of provisions) lead to larger trade liberalization effects. However, we do not see evidence that the increase in the number of investment provisions in DTAs has lead to more FDI. In fact, some of our results suggest that additional provisions and added complexity may make DTAs less effective in promoting FDI. Next, in Section 4.2, we rely on the partial estimates from this section to obtain GE effects of DTAs on FDI.

4.2 Counterfactual Analysis

This section translates the partial equilibrium estimates from Tables 1 and 2 into GE effects of DTAs on FDI. To this end, we rely on the structural trade and investment system from Section 2.1.

We start the analysis by describing the steps that we took to make system (8)-(15) operational for our purposes. For the counterfactual analysis we use as baseline the latest available year in our dataset, which is 2011 and was determined by the availability of capital stock data. In order to perform the counterfactual analysis, we need to set values for the parameters. Some parameters are borrowed from the literature: i) the elasticity of substitution is set equal to $\sigma = 6$, which is standard in the trade literature, ii) the consumer discount factor is set equal to $\beta = 0.98$ (Yao et al., 2012), iii) and the country-specific capital shares of production α_j and the country-specific adjustment costs of capital δ_j are calculated using the Penn World Tables and reported in columns (3) and (4) of Table 5, respectively.

We calibrate other parameters in order to match the observed data. The share of technology capital of a country to all destinations as a share from total world technology capital (η_i) is calculated using FDI_{ij}^{value}:

$$\eta_i = \frac{\sum_j FDI_{ij}^{value}}{\sum_i \sum_j FDI_{ij}^{value}}. \tag{19}$$

ϕ_j is calculated using the relationship between inward FDI ($FDI_j^{in} = \sum_i FDI_{ij}^{value}$) and physical capital in the production function along with FDI and physical capital data and data on the capital shares:

$$\phi_j = \frac{\alpha_j \times (FDI_j^{in}/K_j)}{1 + \alpha_j (FDI_j^{in}/K_j)}. \tag{20}$$

The exact values for η and ϕ are given in columns (5) and (6) of Table 5.

Table 5: Calibrated Parameters

(1) ISO3	(2) Country	(3) α	(4) δ	(5) η	(6) ϕ
AGO	Angola	0.47	0.0528	0.00078	0.056
ARG	Argentina	0.57	0.0394	0.00792	0.024
AUS	Australia	0.44	0.0375	0.01375	0.052
AUT	Austria	0.43	0.0442	0.00521	0.058
AZE	Azerbaijan	0.79	0.0725	0.00058	0.041
BEL	Belgium	0.38	0.0452	0.00677	0.235
BGD	Bangladesh	0.47	0.0407	0.00322	0.003
BGR	Bulgaria	0.51	0.0565	0.00093	0.091
BLR	Belarus	0.48	0.0506	0.00152	0.031
BRA	Brazil	0.44	0.0475	0.02653	0.042
CAN	Canada	0.39	0.0371	0.01658	0.057

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Table 5 – *Continued from previous page*

(1) ISO3	(2) Country	(3) α	(4) δ	(5) η	(6) ϕ
CHE	Switzerland	0.35	0.0568	0.00683	0.190
CHL	Chile	0.55	0.0427	0.00305	0.057
CHN	China	0.46	0.0530	0.18395	0.009
COL	Colombia	0.39	0.0411	0.00536	0.008
CYP	Cyprus	0.48	0.0357	0.00117	0.186
CZE	Czech Republic	0.49	0.0416	0.00359	0.063
DEU	Germany	0.39	0.0389	0.04024	0.031
DNK	Denmark	0.37	0.0431	0.00320	0.054
DOM	Dominican Republic	0.34	0.0307	0.00097	0.009
ECU	Ecuador	0.55	0.0466	0.00160	0.007
EGY	Egypt	0.62	0.0597	0.00351	0.029
ESP	Spain	0.39	0.0375	0.02146	0.047
EST	Estonia	0.42	0.0461	0.00030	0.086
ETH	Ethiopia	0.47	0.0494	0.00073	0.002
FIN	Finland	0.39	0.0412	0.00323	0.049
FRA	France	0.37	0.0382	0.03254	0.036
GBR	United Kingdom	0.39	0.0379	0.02665	0.083
GHA	Ghana	0.47	0.0553	0.00057	0.018
GRC	Greece	0.47	0.0335	0.00396	0.014
GTM	Guatemala	0.58	0.0454	0.00037	0.030
HKG	Hong Kong	0.48	0.0435	0.00687	0.228
HRV	Croatia	0.34	0.0436	0.00106	0.039
HUN	Hungary	0.41	0.0436	0.00229	0.065
IDN	Indonesia	0.54	0.0370	0.01334	0.019
IND	India	0.50	0.0558	0.04216	0.007
IRL	Ireland	0.52	0.0496	0.00238	0.292
IRN	Iran, Islamic Republic of	0.74	0.0588	0.01147	0.001
IRQ	Iraq	0.70	0.0558	0.00099	0.004
ISR	Israel	0.45	0.0448	0.00242	0.026
ITA	Italy	0.46	0.0380	0.03135	0.021
JPN	Japan	0.39	0.0466	0.07416	0.004
KAZ	Kazakhstan	0.58	0.0400	0.00270	0.065
KEN	Kenya	0.57	0.0519	0.00049	0.017
KOR	Korea, Republic of	0.50	0.0501	0.02197	0.012
KWT	Kuwait	0.75	0.0557	0.00204	0.008
LBN	Lebanon	0.56	0.0413	0.00134	0.002
LKA	Sri Lanka	0.31	0.0446	0.00119	0.001
LTU	Lithuania	0.53	0.0418	0.00050	0.058
LUX	Luxembourg	0.46	0.0463	0.00649	0.634
LVA	Latvia	0.45	0.0336	0.00037	0.051
MAR	Morocco	0.51	0.0521	0.00176	0.045
MEX	Mexico	0.61	0.0362	0.01590	0.050
MKD	Macedonia, Republic of	0.47	0.0406	0.00026	0.031
MLT	Malta	0.46	0.0529	0.00015	0.219
MYS	Malaysia	0.47	0.0596	0.00587	0.034
NGA	Nigeria	0.50	0.0581	0.00178	0.050
NLD	Netherlands	0.41	0.0401	0.01680	0.109
NOR	Norway	0.48	0.0399	0.00348	0.094
NZL	New Zealand	0.43	0.0408	0.00124	0.081
OMN	Oman	0.70	0.0602	0.00110	0.029
PAK	Pakistan	0.47	0.0551	0.00468	0.007
PER	Peru	0.69	0.0395	0.00364	0.016
PHL	Philippines	0.64	0.0488	0.00485	0.012
POL	Poland	0.44	0.0491	0.00746	0.046
PRT	Portugal	0.39	0.0351	0.00382	0.043
QAT	Qatar	0.81	0.0960	0.00235	0.034
ROM	Romania, Socialist Republic of	0.53	0.0518	0.00298	0.049
RUS	Russian Federation	0.26	0.0402	0.03052	0.011
SAU	Saudi Arabia	0.72	0.0530	0.00976	0.009
SDN	Sudan	0.41	0.0664	0.00035	0.008
SER	Serbia	0.42	0.0402	0.00103	0.035
SGP	Singapore	0.56	0.0533	0.00494	0.182
SVK	Slovakia	0.46	0.0520	0.00125	0.073
SVN	Slovenia	0.33	0.0439	0.00086	0.023

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Table 5 – *Continued from previous page*

(1) ISO3	(2) Country	(3) α	(4) δ	(5) η	(6) ϕ
SWE	Sweden	0.45	0.0453	0.00408	0.182
SYR	Syrian Arab Republic (Syria)	0.47	0.0552	0.00122	0.003
THA	Thailand	0.61	0.0655	0.00946	0.035
TKM	Turkmenistan	0.47	0.0430	0.00115	0.001
TUN	Tunisia	0.50	0.0474	0.00108	0.005
TUR	Turkey	0.56	0.0554	0.00729	0.037
TZA	Tanzania, United Republic of	0.57	0.0435	0.00055	0.032
UKR	Ukraine	0.44	0.0308	0.00631	0.013
USA	United States of America	0.40	0.0475	0.17546	0.023
UZB	Uzbekistan	0.47	0.0327	0.00099	0.003
VEN	Venezuela, Bolivarian Republic of	0.63	0.0389	0.00366	0.020
VNM	Vietnam	0.47	0.0455	0.00507	0.010
ZAF	South Africa	0.46	0.0506	0.00419	0.066
ZWE	Zimbabwe	0.44	0.0371	0.00004	0.083

Notes: This table reports results from our calibration for some parameters. Column (1) gives the iso3-country codes, column (2) the country names. The country-specific capital shares of production α_j are reported in column (3), while in column (4) we give the values of the country-specific adjustment costs of capital δ. The values for the η's, i.e., the share of technology capital of a country to all destinations, is given in columns (5). Column (6) gives the values for the production share of FDI (ϕ). See text for further details.

For the baseline, we calibrate bilateral trade frictions to the power of $1-\sigma$, i.e., trade openness $t_{ij}^{1-\sigma}$, using data on trade flows, income, and expenditure and solving Equations (9) and (10) for given trade costs and calculating a new matrix $t_{ij}^{1-\sigma}$ using Equation (8) until convergence, where we normalize all internal trade costs and trade costs for one exporter to one. Given trade costs, we can calculate the inward and outward multilateral resistance indexes using Equations (9) and (10), respectively, where we set the inward MRT for Angola to one.

M_j is calibrated using data on income, FDI, and constructed MRTs and the following theory-consistent equation for technology capital:

$$M_j = \frac{\beta \eta_j}{1-\beta+\beta\delta_{j,M}} \left(\left(1 - \phi_j \sum_{\substack{i \neq j, \\ FDI_{ij}>1}} \eta_i \right) \frac{\phi_j Y_j}{P_j} + \sum_{\substack{i \neq j, \\ FDI_{ji}>1}} \frac{\eta_j \phi_i^2 Y_i}{P_j} \right). \tag{21}$$

With this, we can construct FDI openness (ω_{ij}) using the following equation for FDI flows in values:[21]

$$FDI_{ij}^{value} = \omega_{ij} \frac{\beta \eta_i^2}{1 - \beta + \beta \delta_{i,M}} \left(\left(1 - \phi_i \sum_{\substack{k \neq i, \\ FDI_{ki} > 1}} \eta_k \right) \frac{\phi_i Y_i}{P_i} + \sum_{\substack{k \neq i, \\ FDI_{ik} > 1}} \frac{\eta_i \phi_k^2 Y_k}{P_i} \right) \frac{\phi_j Y_j}{M_i}. \tag{22}$$

A_j/γ_j, the preference-adjusted technology, is calibrated using Equations (11) and (12). As the value of domestic income and expenditure calculated from the trade data do not perfectly match up, we define $\psi_j \equiv E_j / \left(Y_j + \eta_j \sum_{i \in \mathbb{N}_{ji,t}} \phi_i Y_i - \phi_j Y_j \sum_{i \in \mathbb{N}_{ij,t}} \eta_i \right)$ as an exogenous country-specific parameter that accounts for these trade imbalances. In the spirit of Dekle et al. (2007, 2008), we first eliminate all exogenous trade imbalances and take the equilibrium without trade imbalances as baseline.

In order to highlight the alternative channels through which DTAs affect FDI, and also to capitalize on the full set of our partial estimates, we perform two sets of experiments. First, we rely on our estimates of the dummy variables for DTAs and DTAs with investment provisions from column (2) of Table 1 and column (3) of Table 2, respectively. Then, we also obtain corresponding effects based on the estimates of the continuous depth variables from column (3) of Table 1 and column (4) of Table 2. Consistent with the discussion in Section 2.2, we perform each of the two experiments in two steps. First, we change the vector of FDI frictions. Then, in addition, we change the vector of trade costs. As the DTAs are already in place, we perform an ex-post evaluation, i.e., we assume that in the baseline the agreement is in place and simulate the effect without DTAs as counterfactual. We then report the change from the baseline to the counterfactual, i.e., baseline value minus counterfactual value relative to the counterfactual value.

[21] The values of ω_{ij} are restricted to be between zero and one. Hence, we normalize each row by the maximum element. Further, all zero FDI flows are leading to zero ω_{ij}'s by construction. To avoid this, we set $\omega_{ij} M_i = 1.00001$ for those observations.

Table 6: Total GE Effects on Inward and Outward FDI

ISO3	Panel A: Dummy DTA variable				Panel B: Continuous DTA variable			
	FDI lib.		FDI and trade lib.		FDI lib.		FDI and trade lib.	
	inw. FDI	outw. FDI	inw. FDI	outw. FDI	inw. FDI	outw. FDI	inw. FDI	outw. FDI
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
AGO	0.12	0.00	0.59	0.00	0.13	0.00	0.42	0.00
ARG	1.15	0.53	2.06	1.55	1.37	0.65	1.95	1.08
AUS	6.93	4.47	7.90	4.85	6.36	3.72	6.97	4.04
AUT	0.99	0.53	1.86	1.75	1.35	0.77	1.91	1.43
AZE	0.24	0.00	1.12	0.01	0.25	0.00	0.82	0.01
BEL	1.01	1.00	1.93	1.45	1.36	1.39	1.95	1.66
BGD	0.24	0.02	1.09	0.17	0.25	0.02	0.80	0.05
BGR	0.92	0.10	1.80	0.26	1.24	0.14	1.78	0.23
BLR	0.22	0.01	1.01	0.10	0.23	0.01	0.72	0.04
BRA	0.60	1.77	1.52	2.58	0.69	2.16	1.28	2.47
CAN	6.16	3.25	7.07	6.29	7.13	3.25	7.72	6.75
CHE	3.47	1.96	4.35	2.62	3.28	2.28	3.84	2.52
CHL	17.97	2.50	18.93	3.04	21.01	3.29	21.65	3.70
CHN	1.43	69.50	2.33	90.59	1.04	51.93	1.61	61.73
COL	1.54	0.52	2.24	0.74	1.58	0.59	2.03	0.72
CYP	0.82	0.06	1.48	0.18	1.13	0.09	1.54	0.16
CZE	1.00	0.14	1.89	0.36	1.35	0.21	1.92	0.34
DEU	1.00	5.31	1.88	10.94	1.35	7.39	1.92	10.53
DNK	1.00	0.42	1.92	1.01	1.35	0.58	1.94	0.91
DOM	10.17	0.06	10.78	0.12	10.23	0.06	10.65	0.12
ECU	0.14	0.00	0.68	0.06	0.15	0.00	0.50	0.02
EGY	0.16	0.02	0.79	0.49	0.17	0.02	0.55	0.17
ESP	0.96	2.14	1.80	4.31	1.31	2.90	1.85	4.11
EST	0.23	0.02	1.09	0.03	0.24	0.02	0.79	0.03
ETH	0.11	0.01	0.48	0.04	0.12	0.01	0.35	0.03
FIN	0.98	0.32	1.84	0.72	1.33	0.47	1.89	0.70
FRA	1.01	3.35	1.95	7.58	1.35	4.89	1.95	7.25
GBR	0.99	3.61	1.90	7.01	1.34	5.02	1.92	6.96
GHA	0.13	0.02	0.63	0.03	0.14	0.02	0.44	0.02
GRC	0.87	0.17	1.66	0.54	1.18	0.24	1.67	0.45
GTM	5.53	0.01	6.02	0.04	5.06	0.01	5.38	0.04
HKG	0.21	0.07	0.93	0.56	0.22	0.07	0.67	0.24
HRV	0.24	0.07	1.00	0.07	0.28	0.11	0.75	0.12
HUN	0.93	0.16	1.81	0.56	1.23	0.23	1.80	0.46
IDN	10.66	2.12	11.47	3.53	8.00	1.65	8.50	2.51
IND	4.31	11.85	5.25	15.97	3.52	9.43	4.11	11.44
IRL	0.97	0.30	1.81	0.74	1.32	0.43	1.87	0.68
IRN	0.10	0.05	0.51	0.54	0.11	0.06	0.34	0.25
IRQ	0.11	0.00	0.46	0.03	0.11	0.00	0.34	0.00
ISR	0.19	0.02	0.90	0.30	0.21	0.02	0.67	0.14
ITA	1.04	4.22	1.99	7.80	1.40	5.82	2.00	7.82
JPN	3.51	27.05	4.39	33.86	3.25	25.62	3.82	29.94
KAZ	0.22	0.01	1.07	0.09	0.23	0.01	0.77	0.04
KEN	0.18	0.00	0.87	0.01	0.20	0.00	0.63	0.01
KOR	10.07	23.79	11.07	26.18	12.10	28.46	12.75	29.89
KWT	0.11	0.00	0.50	0.01	0.12	0.00	0.36	0.00
LBN	0.12	0.03	0.63	0.22	0.13	0.04	0.44	0.13
LKA	0.13	0.02	0.58	0.16	0.14	0.03	0.41	0.09
LTU	0.89	0.02	1.78	0.05	1.19	0.03	1.76	0.05
LUX	0.96	0.99	1.74	1.52	1.31	1.42	1.80	1.74
LVA	0.82	0.00	1.48	0.03	1.12	0.00	1.53	0.02
MAR	5.50	0.07	6.21	0.36	5.20	0.07	5.62	0.19
MEX	8.72	3.60	9.72	8.56	9.77	4.00	10.41	8.88
MKD	6.45	0.10	7.15	0.12	9.84	0.15	10.29	0.16
MLT	0.90	0.01	1.54	0.04	1.26	0.01	1.66	0.03
MYS	10.67	1.22	11.51	2.01	7.71	0.91	8.22	1.41
NGA	0.22	0.00	0.93	0.03	0.23	0.00	0.67	0.01
NLD	1.04	1.81	1.99	5.38	1.40	2.64	2.00	4.64
NOR	1.51	0.70	2.43	1.04	1.64	0.89	2.22	1.16
NZL	7.45	0.29	8.32	0.33	5.33	0.21	5.88	0.25
OMN	5.47	0.05	6.07	0.06	5.16	0.04	5.52	0.05

Continued on next page

Table 6 – *Continued from previous page*

	Panel A: Dummy DTA variable				Panel B: Continuous DTA variable			
ISO3	FDI lib.		FDI and trade lib.		FDI lib.		FDI and trade lib.	
	inw. FDI	outw. FDI	inw. FDI	outw. FDI	inw. FDI	outw. FDI	inw. FDI	outw. FDI
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PAK	5.96	0.13	6.63	0.51	7.67	0.14	8.09	0.32
PER	13.33	0.42	14.26	0.74	12.90	0.39	13.50	0.65
PHL	10.72	0.77	11.59	1.78	7.72	0.59	8.25	1.23
POL	1.01	0.52	1.94	1.44	1.36	0.77	1.95	1.29
PRT	0.86	0.26	1.67	0.87	1.17	0.38	1.69	0.72
QAT	0.16	0.01	0.72	0.02	0.16	0.01	0.51	0.01
ROM	0.19	0.01	0.95	-0.01	0.21	0.02	0.67	0.00
RUS	0.24	0.29	1.13	1.06	0.26	0.31	0.82	0.70
SAU	0.18	0.03	0.87	0.12	0.19	0.04	0.63	0.07
SDN	0.06	0.00	0.26	0.00	0.06	0.00	0.17	0.00
SER	0.23	0.00	1.04	0.00	0.24	0.00	0.74	0.00
SGP	16.96	3.47	17.89	5.02	13.62	2.82	14.18	3.99
SVK	0.91	0.01	1.81	0.08	1.21	0.02	1.79	0.06
SVN	0.88	0.06	1.69	0.10	1.19	0.08	1.69	0.11
SWE	0.96	0.46	1.73	1.23	1.31	0.67	1.79	1.12
SYR	0.11	0.01	0.52	0.09	0.12	0.01	0.37	0.03
THA	10.72	1.56	11.62	3.22	7.78	1.23	8.32	2.34
TKM	0.06	0.01	0.33	0.07	0.07	0.01	0.21	0.04
TUN	0.14	0.01	0.67	0.20	0.15	0.01	0.46	0.10
TUR	0.23	0.05	1.06	0.70	0.24	0.05	0.75	0.33
TZA	0.19	0.00	0.87	0.04	0.20	0.00	0.63	0.01
UKR	0.16	0.02	0.81	0.28	0.17	0.03	0.56	0.11
USA	2.07	72.87	3.01	87.52	2.18	70.94	2.78	83.34
UZB	0.12	0.00	0.55	0.04	0.13	0.00	0.39	0.01
VEN	1.26	0.24	2.12	0.32	1.51	0.30	2.06	0.33
VNM	10.65	0.11	11.39	0.37	7.99	0.09	8.43	0.26
ZAF	0.24	0.02	1.10	0.14	0.25	0.02	0.78	0.08
ZWE	0.12	0.00	0.59	0.00	0.13	0.00	0.41	0.00
World	2.77	72.87	3.67	87.52	2.79	70.94	3.36	83.34
Lib-Countries	3.00	72.87	3.69	87.52	3.01	70.94	3.38	83.34
ROW	0.54	0.01	0.98	0.00	0.64	0.01	0.70	0.00

Notes: This table reports results from our counterfactual analysis. Column (1) gives the iso3-country codes. Panel A reports results based a uniform change in the bilateral FDI frictions between all countries that have signed a DTA with investment provisions that is based on our estimate of 0.295. Columns (2) and (3) report the percentage changes in inward and outward FDI, respectively, when DTAs change FDI frictions, while in columns (4) and (5) in addition to the change in FDI frictions DTAs also change trade frictions. Panel B reports results based on the estimates on the continuous depth variables. Columns (6) and (7) report the percentage changes in inward and outward FDI, respectively, when DTAs change FDI frictions, while in columns (8) and (9) in addition to the change in FDI frictions DTAs also change trade frictions.

Given the main purpose of our analysis, and to keep the presentation of our results manageable, we focus the discussion of our counterfactual results on the percentage changes (between the baseline and the counterfactual scenarios) in the stocks of FDI per country. Specifically, we construct and report percentage changes in inward and outward FDI stocks, i.e., the percentage changes in technology capital used in total at home and technology capital from one country used abroad:

$$\%\Delta FDI^{in} = (FDI_j^{in,b} - FDI_j^{in,c})/FDI_j^{in,c} \times 100, \tag{23}$$

$$\%\Delta FDI^{out} = (FDI_j^{out,b} - FDI_j^{out,c})/FDI_j^{out,c} \times 100, \tag{24}$$

where superscript b denote baseline values with DTAs in place, and superscript c the counterfactual situation without DTAs in place, and, consistent with our theory, inward FDI and outward FDI stocks per country can be calculated as follows:

$$FDI_j^{in} \quad = \prod_{i=1}^{N} \left(\max\{1, \omega_{ij} M_i\}\right)^{\eta_i}, \tag{25}$$

$$FDI_i^{out} \quad = \prod_{j=1}^{N} \left(\max\{1, \omega_{ij} M_i\}\right)^{\eta_i}. \tag{26}$$

Note that the inward FDI stock can be seen as the global technology stock applied locally, whereas the outward FDI stock is the usage of a countries' technology capital abroad. η determines the usage of FDI abroad of one country, i.e., outward FDI stocks per country will change a lot if this share is large (i.e., η is large), even if the change in technology capital M_i is comparably small. This is a result of the non-rival nature of FDI that we capture. On the other hand side, for inward FDI per country the η's always sum to one and therefore changes in inward FDI are a weighted average of changes in the $\omega_{ij} M_i$'s.

Before we discuss our findings, we draw the reader's attention to a caveat with our GE analysis, which is due to the fact that the underlying theory is based on the assumption of non-rival technology FDI, while our data includes all/aggregate FDI flows. This gap, of course, has implications for the quantitative results. Therefore, the specific indexes that we obtain and report in this section should be interpreted accordingly and with caution. Nevertheless, we believe that the main conclusions and policy implications that we will draw in this section about a disproportionately large impact of outward FDI will remain qualitatively the same if applied to appropriate data on technology FDI.

Our findings are reported in Table 6, where the first column lists the ISO3 country codes for the countries in our sample, Panel A reports the results from the scenario based on the estimates of the dummy DTA variables, and Panel B reports the effects that are based on the estimates of the continuous depth variables.

The results in columns (2) and (3) of Table 6 are obtained in response to a uniform change in the bilateral FDI frictions between all countries that have signed a DTA with investment provisions that is based on our estimate of 0.295 (std.err. 0.108) from column (3) of Table 2. There are several things noteworthy. First, both inward and outward FDI increase for most of the countries. For the countries that have signed a DTA, the effect for inward FDI is on average an about 3% increase, while it amounts to 72% for outward FDI. The huge values for outward FDI are driven by the importance of USA and China as the largest outward FDI countries. Their technology capital as a share from total world technology capital (i.e., their η's) are about 18% (see Table 5). Hence, their stocks are used substantially in many countries of the world (the exact usage at the bilateral level also depends on the FDI frictions ω). Even though USA and China only increase their technology capital stock (M) by about 0.7% and 1%, respectively, the effect on their outward FDI stocks is large due to the huge share of their FDI in world FDI and the non-rival nature, allowing to use the technology capital in all countries in the world simultaneously.

On the inward FDI side, we see the largest increase for Chile, Singapore, Peru, Thailand, the Philippines, Malaysia, Indonesia, Vietnam, the Dominican Republic and Korea. Those are all countries that have many DTAs and also rely substantially on inward FDI. On the other end of the spectrum are countries that are hardly affected, neither on the inward nor on the export side, such as Sudan, Turkmenistan, Iran, and Iraq. Those countries do not have many (or any) DTAs in place and are also relatively closed in terms of FDI. Overall, we see a wide heterogeneity amongst countries. This is even more extreme for outward FDI, where the importance of the large outward FDI investors is very dominant.

The estimates in columns (4) and (5) of Table 6 are obtained when, in addition to the change in bilateral FDI frictions, we also change uniformly the vector of bilateral trade frictions based on our estimate from column (2) of Table 1. Relative to the scenario where only the bilateral FDI frictions are changed (i.e., the results presented in columns (2) and (3) of Table 6), we see qualitatively a very similar picture and quantitatively an increase in both, inward and outward FDI. Specifically, on average, trade liberalization has contributed to 0.7 percentage points (or about 25%) increase in inward FDI and about 15 percentage points in outward FDI. These estimates reveal that trade liberalization via DTAs is an important channel to stimulate FDI, thus complementing the results from Anderson et al. (2019), who show that FDI liberalization is important for trade.

Panel B of Table 6 reports estimates that are obtained based on the estimates on the continuous depth variables from Section 4.1. The estimates in columns (6) and (7) rely on the estimates from column (4) of Table 2. Allowing for the continuous depth leads overall quantitatively and qualitatively similar results, with heterogeneous changes across countries. Finally, the estimates in columns (8) and (9) of Table 6 are obtained when, in addition to the change in bilateral FDI frictions, we also change the vector of bilateral trade frictions based on our estimate from column (3) of Table 1. Similar to the uniform changes, the additional allowance for changes of bilateral trade frictions leads to larger effects for inward and outward FDI.

To sum up, according to our analysis, the DTAs that were in force in 2011 have contributed to about 3% of inward FDI in the world and about 70% of outward FDI. The latter is heavily driven by the fact that some countries have large stocks of FDI used in many countries in the world, multiplying the effect of any change in outward FDI of those countries due to changes in frictions.

5 Conclusion

The objective of this paper was to study the links between deep trade liberalization in the form of DTAs and FDI. To this end, we identified and decomposed three channels through which DTAs impact FDI. First, we obtained significant direct/partial equilibrium effects of DTAs and their investment provisions on FDI from a theory-motivated FDI gravity model. Second, we translated the partial estimates of the DTA effects on FDI into GE effects. This analysis highlighted the importance of the GE links between DTAs and FDI, and uncovered significant asymmetries in the response of inward vs. outward FDI in our model. Finally, we performed counterfactual analysis of the impact of deep trade liberalization on FDI, which revealed that, through their impact on trade, DTAs promote FDI additionally.

While, as discussed earlier, our counterfactual analysis is subject to criticism on the mismatch between the data used and the underlying theory, we believe that our conclusions about the disproportionately large impact of outward FDI would remain qualitatively the same if applied to appropriate data on technology FDI. We view this finding as novel and potentially important from a policy perspective, both for the negotiations of trade and investment agreements and for properly quantifying their implications. Moreover, we see significant potential in developing and utilizing datasets on global technology transfers that would generate more precise partial estimates and more informative GE analysis of the links between trade liberalization and FDI and lead to clearer policy recommendations. In addition to the theory on the intensive margin that we utilize here, we expect significant payoffs from developing theories that would capture the links between trade liberalization and the extensive margins (both domestic and international) of technology capital and its diffusion in the global economy.

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Appendix

For the convenience of the reader, the following is a replication of the online Appendix from Anderson et al. (2019). It includes all derivations leading to the structural system of trade and investment used in this paper along with some further derivations that may aid intuition and the discussion of our results.

A Derivation of System of Equations (8)-(15)

This appendix gives derivation details for our system of Equations (8)-(15).

First, let us re-state our production function as given in Equation (12), allowing also ϕ to vary by country:

$$Y_{j,t} = p_{j,t} A_{j,t} \left(L_{j,t}^{1-\alpha_j} K_{j,t}^{\alpha_j} \right)^{1-\phi_j} \left(\prod_{i=1}^{N} \left(\max\{1, \omega_{ij,t} M_{i,t}\} \right)^{\eta_i} \right)^{\phi_j} \quad \alpha_j, \phi_j, \eta_i \in (0,1). \tag{A1}$$

Note that we can write $\max\{1, \omega_{ij,t} M_{i,t}\} = (1 + \omega_{ij,t} M_{i,t} + |1 - \omega_{ij,t} M_{i,t}|)/2 = (1 + \omega_{ij,t} M_{i,t} + ((1 - \omega_{ij,t} M_{i,t})^2)^{1/2})/2$.[22] The derivative of $\max\{1, \omega_{ij,t} M_{i,t}\}$ with respect to $M_{i,t}$ is given by:

$$\begin{aligned} \frac{\partial \left(\max\{1, \omega_{ij,t} M_{i,t}\} \right)}{\partial M_{i,t}} &= \left(\omega_{ij,t} - \frac{(1 - \omega_{ij,t} M_{i,t})}{((1 - \omega_{ij,t} M_{i,t})^2)^{1/2}} \omega_{ij,t} \right) /2 \\ &= \left(1 - \frac{(1 - \omega_{ij,t} M_{i,t})}{|1 - \omega_{ij,t} M_{i,t}|} \right) \frac{\omega_{ij,t}}{2}. \end{aligned} \tag{A2}$$

Using this definition of nominal output, the value marginal product of technology capital at home is given by:

$$\frac{\partial Y_{j,t}}{\partial M_{j,t}} = \frac{\phi_j \eta_j Y_{j,t}}{\max\{1, \omega_{jj,t} M_{j,t}\}} \left(1 - \frac{(1 - \omega_{jj,t} M_{j,t})}{|1 - \omega_{jj,t} M_{j,t}|} \right) \frac{\omega_{jj,t}}{2}, \tag{A3}$$

[22] See for example https://math.stackexchange.com/questions/429622/show-that-the-max-x-y-fracxyx-y2.

and the value marginal product of $M_{j,t}$ abroad by:

$$\frac{\partial Y_{i,t}}{\partial M_{j,t}} = \frac{\eta_j \phi_i Y_{i,t}}{\max\{1, \omega_{ji,t} M_{j,t}\}} \left(1 - \frac{(1-\omega_{ji,t} M_{j,t})}{|1-\omega_{ji,t} M_{j,t}|}\right) \frac{\omega_{ji,t}}{2}. \tag{A4}$$

Note that an alternative way of writing these two conditions is the following:

$$\frac{\partial Y_{j,t}}{\partial M_{j,t}} = \begin{cases} \frac{\eta_j \phi_j Y_{j,t}}{M_{j,t}} & \text{if} \quad \omega_{jj,t} M_{j,t} > 1, \\ 0 & \text{if} \quad \omega_{jj,t} M_{j,t} \leq 1. \end{cases}$$

$$\frac{\partial Y_{i,t}}{\partial M_{j,t}} = \begin{cases} \frac{\eta_j \phi_i Y_{i,t}}{M_{j,t}} & \text{if} \quad \omega_{ji,t} M_{j,t} > 1, \\ 0 & \text{if} \quad \omega_{ji,t} M_{j,t} \leq 1. \end{cases}$$

With these new expressions for the value marginal products, disposable income can be written as:

$$\begin{aligned} E_{j,t} = Y_{j,t} &+ \eta_j M_{j,t} \sum_{i \neq j} \frac{\phi_i Y_{i,t}}{\max\{1, \omega_{ji,t} M_{j,t}\}} \left(1 - \frac{(1-\omega_{ji,t} M_{j,t})}{|1-\omega_{ji,t} M_{j,t}|}\right) \frac{\omega_{ji,t}}{2} \\ &- \phi_j Y_{j,t} \sum_{i \neq j} \frac{\eta_i M_{i,t}}{\max\{1, \omega_{ij,t} M_{i,t}\}} \left(1 - \frac{(1-\omega_{ij,t} M_{i,t})}{|1-\omega_{ij,t} M_{i,t}|}\right) \frac{\omega_{ij,t}}{2}, \end{aligned} \tag{A5}$$

which describes expenditure as the sum of total nominal output ($Y_{j,t}$) plus rents from foreign investments ($\sum_{i \neq j} M_{j,t} \times \frac{\partial Y_{i,t}}{\partial M_{j,t}}$), minus rents accruing to foreign investments ($\sum_{i \neq j} M_{i,t} \times \frac{\partial Y_{j,t}}{\partial M_{i,t}}$), which are part of nominal output. Rewriting a bit further, we end up with:

$$E_{j,t} = Y_{j,t} + \eta_j \sum_{\substack{i \neq j, \\ \omega_{ji,t} M_{j,t} > 1}} \phi_i Y_{i,t} - \phi_j Y_{j,t} \sum_{\substack{i \neq j, \\ \omega_{ij,t} M_{i,t} > 1}} \eta_i. \tag{A6}$$

In the next subsection, we first derive the solution of the dynamic problem. Afterward, we state the steady-state of the system. At the end, we derive our FDI gravity system.

A.1 Solving the 'Upper Level'

This section details the Lagrangian problem and the corresponding first-order conditions for the 'upper level' optimization problem leading to the structural dynamic system of trade, growth, and FDI.

We assume a log-intertemporal utility function:

$$U_{j,t} = \sum_{t=0}^{\infty} \beta^t \ln(C_{j,t}), \tag{A7}$$

and combine the budget constraint given by Equation (5) with the expenditure function given by Equation (A6):

$$\begin{aligned} P_{j,t}C_{j,t} + P_{j,t}\Omega_{j,t} + P_{j,t}\chi_{j,t} &= Y_{j,t} + \eta_j \sum_{\substack{i \neq j, \\ \omega_{ji,t}M_{j,t} > 1}} \phi_i Y_{i,t} - \phi_j Y_{j,t} \sum_{\substack{i \neq j, \\ \omega_{ij,t}M_{i,t} > 1}} \eta_i \\ &= \left(1 - \phi_j \sum_{\substack{i \neq j, \\ \omega_{ij,t}M_{i,t} > 1}} \eta_i \right) Y_{j,t} + \eta_j \sum_{\substack{i \neq j, \\ \omega_{ji,t}M_{j,t} > 1}} \phi_i Y_{i,t}. \end{aligned}$$

Further, we replace $Y_{j,t}$ with the production function as formulated in Equation (A1), leading to:

$$\begin{aligned} & P_{j,t}C_{j,t} + P_{j,t}\Omega_{j,t} + P_{j,t}\chi_{j,t} = \\ & \left(1 - \phi_j \sum_{\substack{i \neq j, \\ \omega_{ij,t}M_{i,t} > 1}} \eta_i \right) p_{j,t} A_{j,t} \left(L_{j,t}^{1-\alpha_j} K_{j,t}^{\alpha_j} \right)^{1-\phi_j} \left(\prod_{i=1}^{N} \left(\max\{1, \omega_{ij,t}M_{i,t}\} \right)^{\eta_i} \right)^{\phi_j} \\ & + \eta_j \sum_{\substack{i \neq j, \\ \omega_{ji,t}M_{j,t} > 1}} \phi_i p_{i,t} A_{i,t} \left(L_{i,t}^{1-\alpha_i} K_{i,t}^{\alpha_i} \right)^{1-\phi_i} \left(\prod_{k=1}^{N} \left(\max\{1, \omega_{ki,t}M_{k,t}\} \right)^{\eta_k} \right)^{\phi_i}. \end{aligned}$$

In order to end up with only one constraint, we also replace $\Omega_{j,t}$ and $\chi_{j,t}$ by using:

$$\Omega_{j,t} = K_{j,t+1} - (1-\delta_{j,K})\, K_{j,t},$$
$$\chi_{j,t} = M_{j,t+1} - (1-\delta_{j,M})\, M_{j,t},$$

leading to the following budget constraint:

$$\begin{aligned} P_{j,t}C_{j,t} + P_{j,t}\left(K_{j,t+1} - (1-\delta_{j,K})\, K_{j,t}\right) + P_{j,t}\left(M_{j,t+1} - (1-\delta_{j,M})\, M_{j,t}\right) = \\ \left(1 - \phi_j \sum_{\substack{i\neq j,\\ \omega_{ij,t}M_{i,t}>1}} \eta_i\right) p_{j,t}A_{j,t}\left(L_{j,t}^{1-\alpha_j}K_{j,t}^{\alpha_j}\right)^{1-\phi_j}\left(\prod_{i=1}^{N}\left(\max\{1,\omega_{ij,t}M_{i,t}\}\right)^{\eta_i}\right)^{\phi_j} \\ +\eta_j \sum_{\substack{i\neq j,\\ \omega_{ji,t}M_{j,t}>1}} \phi_i p_{i,t}A_{i,t}\left(L_{i,t}^{1-\alpha_i}K_{i,t}^{\alpha_i}\right)^{1-\phi_i}\left(\prod_{k=1}^{N}\left(\max\{1,\omega_{ki,t}M_{k,t}\}\right)^{\eta_k}\right)^{\phi_i}. \end{aligned}$$

The corresponding expression for the Lagrangian is:

$$\begin{aligned} \mathcal{L}_j \;=\; & \sum_{t=0}^{\infty}\beta^t\Big[\ln(C_{j,t}) + \lambda_{j,t}\Big((1-\phi_j \sum_{\substack{i\neq j,\\ \omega_{ij,t}M_{i,t}>1}} \eta_i)p_{j,t}A_{j,t}\left(L_{j,t}^{1-\alpha_j}K_{j,t}^{\alpha_j}\right)^{1-\phi_j} \\ & \times\left(\prod_{i=1}^{N}\left(\max\{1,\omega_{ij,t}M_{i,t}\}\right)^{\eta_i}\right)^{\phi_j} \\ & +\eta_j \sum_{\substack{i\neq j,\\ \omega_{ji,t}M_{j,t}>1}} \phi_i p_{i,t}A_{i,t}\left(L_{i,t}^{1-\alpha_i}K_{i,t}^{\alpha_i}\right)^{1-\phi_i}\left(\prod_{k=1}^{N}\left(\max\{1,\omega_{ki,t}M_{k,t}\}\right)^{\eta_k}\right)^{\phi_i} \\ & -P_{j,t}C_{j,t} - P_{j,t}\left(K_{j,t+1} - (1-\delta_{j,K})\, K_{j,t}\right) - P_{j,t}\left(M_{j,t+1} - (1-\delta_{j,M})\, M_{j,t}\right)\Big)\Big]. \end{aligned}$$

Take derivatives with respect to $C_{j,t}$, $K_{j,t+1}$, $M_{j,t+1}$ and $\lambda_{j,t}$ to obtain the following set of first-order conditions:

$$\frac{\partial \mathcal{L}_j}{\partial C_{j,t}} = \frac{\beta^t}{C_{j,t}} - \beta^t \lambda_{j,t} P_{j,t} \overset{!}{=} 0 \quad \text{for all } j \text{ and } t. \tag{A8}$$

$$\begin{aligned} \frac{\partial \mathcal{L}_j}{\partial K_{j,t+1}} = \; & \beta^{t+1} \lambda_{j,t+1} \left(1 - \phi_j \sum_{\substack{i \neq j, \\ \omega_{ij,t+1} M_{i,t+1} > 1}} \eta_i \right) (1 - \phi_j) \alpha_j \frac{Y_{j,t+1}}{K_{j,t+1}} \\ & - \beta^t \lambda_{j,t} P_{j,t} \\ & + \beta^{t+1} \lambda_{j,t+1} P_{j,t+1} (1 - \delta_{j,K}) \overset{!}{=} 0 \quad \text{for all } j \text{ and } t. \end{aligned} \tag{A9}$$

$$\begin{aligned} \frac{\partial \mathcal{L}_j}{\partial M_{j,t+1}} = \; & \beta^{t+1} \lambda_{j,t+1} \left(1 - \phi_j \sum_{\substack{i \neq j, \\ \omega_{ij,t+1} M_{i,t+1} > 1}} \eta_i \right) \frac{\eta_j \phi_j Y_{j,t+1}}{\max\{1, \omega_{jj,t+1} M_{j,t+1}\}} \\ & \times \left(1 - \frac{(1 - \omega_{jj,t+1} M_{j,t+1})}{|1 - \omega_{jj,t+1} M_{j,t+1}|} \right) \frac{\omega_{jj,t+1}}{2} \\ & + \beta^{t+1} \lambda_{j,t+1} \eta_j \\ & \times \sum_{\substack{i \neq j, \\ \omega_{ji,t+1} M_{j,t+1} > 1}} \frac{\eta_j \phi_i^2 Y_{i,t+1}}{\max\{1, \omega_{ji,t+1} M_{j,t+1}\}} \left(1 - \frac{(1 - \omega_{ji,t+1} M_{j,t+1})}{|1 - \omega_{ji,t+1} M_{j,t+1}|} \right) \frac{\omega_{ji,t+1}}{2} \\ & - \beta^t \lambda_{j,t} P_{j,t} \\ & + \beta^{t+1} \lambda_{j,t+1} P_{j,t+1} (1 - \delta_{j,M}) \overset{!}{=} 0 \quad \text{for all } j \text{ and } t. \end{aligned} \tag{A10}$$

$$
\begin{aligned}
\frac{\partial \mathcal{L}_j}{\partial \lambda_{j,t}} = & \left(1-\phi_j \sum_{\substack{i\neq j,\\ \omega_{ij,t}M_{i,t}>1}} \eta_i\right) p_{j,t}A_{j,t}\left(L_{j,t}^{1-\alpha_j}K_{j,t}^{\alpha_j}\right)^{1-\phi_j}\left(\prod_{i=1}^{N}\left(\max\{1,\omega_{ij,t}M_{i,t}\}\right)^{\eta_i}\right)^{\phi_j} \\
& +\eta_j \sum_{\substack{i\neq j,\\ \omega_{ji,t}M_{j,t}>1}} \phi_i p_{i,t}A_{i,t}\left(L_{i,t}^{1-\alpha_i}K_{i,t}^{\alpha_i}\right)^{1-\phi_i}\left(\prod_{k=1}^{N}\left(\max\{1,\omega_{ki,t}M_{k,t}\}\right)^{\eta_k}\right)^{\phi_i} \\
& -P_{j,t}C_{j,t}-P_{j,t}\left(K_{j,t+1}-\left(1-\delta_{j,K}\right)K_{j,t}\right)-P_{j,t}\left(M_{j,t+1}-\left(1-\delta_{j,M}\right)M_{j,t}\right) \\
& \overset{!}{=} 0 \quad \text{for all } j \text{ and } t. \qquad \text{(A11)}
\end{aligned}
$$

Use the first-order condition for consumption to express $\lambda_{j,t}$ as:

$$
\lambda_{j,t} = \frac{1}{C_{j,t}P_{j,t}}. \qquad \text{(A12)}
$$

Replace this in the first-order condition for physical capital:

$$
\begin{aligned}
\frac{\partial \mathcal{L}_j}{\partial K_{j,t+1}} = & \beta^{t+1}\frac{1}{C_{j,t+1}P_{j,t+1}}\left(1-\phi_j \sum_{\substack{i\neq j,\\ \omega_{ij,t+1}M_{i,t+1}>1}} \eta_i\right)(1-\phi_j)\alpha_j\frac{Y_{j,t+1}}{K_{j,t+1}} \\
& -\beta^{t}\frac{P_{j,t}}{C_{j,t}P_{j,t}} \\
& +\beta^{t+1}\frac{P_{j,t+1}}{C_{j,t+1}P_{j,t+1}}\left(1-\delta_{j,K}\right) \overset{!}{=} 0 \quad \text{for all } j \text{ and } t. \qquad \text{(A13)}
\end{aligned}
$$

Simplify and re-arrange to obtain:

$$
\begin{aligned}
\beta\left(1-\phi_j \sum_{\substack{i\neq j,\\ \omega_{ij,t+1}M_{i,t+1}>1}} \eta_i\right)\alpha_j(1-\phi_j)\frac{Y_{j,t+1}}{K_{j,t+1}}-\frac{C_{j,t+1}P_{j,t+1}}{C_{j,t}} = & \\
-\beta\left(1-\delta_{j,K}\right)P_{j,t+1} \quad \text{for all } j \text{ and } t. \qquad \text{(A14)}
\end{aligned}
$$

Now replace λ_j with the expression from the first-order condition for consumption given in Equation (A12) in the first-order condition for technology capital given in Equation (A10):

$$\begin{aligned}
\frac{\partial \mathcal{L}_j}{\partial M_{j,t+1}} = \; & \beta^{t+1} \frac{1}{C_{j,t+1} P_{j,t+1}} \left(1 - \phi_j \sum_{\substack{i \neq j, \\ \omega_{ij,t+1} M_{i,t+1} > 1}} \eta_i \right) \\
& \times \frac{\eta_j \phi_j Y_{j,t+1}}{\max\{1, \omega_{jj,t+1} M_{j,t+1}\}} \left(1 - \frac{(1 - \omega_{jj,t+1} M_{j,t+1})}{|1 - \omega_{jj,t+1} M_{j,t+1}|} \right) \frac{\omega_{jj,t+1}}{2} \\
& + \beta^{t+1} \frac{1}{C_{j,t+1} P_{j,t+1}} \eta_j \\
& \times \sum_{\substack{i \neq j, \\ \omega_{ji,t+1} M_{j,t+1} > 1}} \frac{\eta_j \phi_i^2 Y_{i,t+1}}{\max\{1, \omega_{ji,t+1} M_{j,t+1}\}} \left(1 - \frac{(1 - \omega_{ji,t+1} M_{j,t+1})}{|1 - \omega_{ji,t+1} M_{j,t+1}|} \right) \frac{\omega_{ji,t+1}}{2} \\
& - \beta^t \frac{1}{C_{j,t}} \\
& + \frac{\beta^{t+1}}{C_{j,t+1}} (1 - \delta_{j,M}) \stackrel{!}{=} 0 \quad \text{for all } j \text{ and } t.
\end{aligned} \tag{A15}$$

Simplify and re-arrange to obtain:

$$\begin{aligned}
& \beta \left(1 - \phi_j \sum_{\substack{i \neq j, \\ \omega_{ij,t+1} M_{i,t+1} > 1}} \eta_i \right) \frac{\eta_j \phi_j Y_{j,t+1}}{\max\{1, \omega_{jj,t+1} M_{j,t+1}\}} \left(1 - \frac{(1 - \omega_{jj,t+1} M_{j,t+1})}{|1 - \omega_{jj,t+1} M_{j,t+1}|} \right) \frac{\omega_{jj,t+1}}{2} \\
& \quad + \beta \eta_j \sum_{\substack{i \neq j, \\ \omega_{ji,t+1} M_{j,t+1} > 1}} \frac{\eta_j \phi_i^2 Y_{i,t+1}}{\max\{1, \omega_{ji,t+1} M_{j,t+1}\}} \left(1 - \frac{(1 - \omega_{ji,t+1} M_{j,t+1})}{|1 - \omega_{ji,t+1} M_{j,t+1}|} \right) \frac{\omega_{ji,t+1}}{2} \\
& \quad - \frac{C_{j,t+1} P_{j,t+1}}{C_{j,t}} = \\
& \quad \beta (1 - \delta_{j,M}) P_{j,t+1} \quad \text{for all } j \text{ and } t.
\end{aligned} \tag{A16}$$

Assuming that for sure $\omega_{jj,t+1} M_{j,t+1} > 1$, i.e., technology stock at home is positive and frictions small (i.e., $\omega_{jj,t+1}$ sufficiently large), we may simplify as follows:

$$\beta\left(1-\phi_j\sum_{\substack{i\neq j,\\ \omega_{ij,t+1}M_{i,t+1}>1}}\eta_i\right)\frac{\eta_j\phi_jY_{j,t+1}}{M_{j,t+1}}+\beta\eta_j\sum_{\substack{i\neq j,\\ \omega_{ji,t+1}M_{j,t+1}>1}}\frac{\eta_j\phi_i^2Y_{i,t+1}}{M_{j,t+1}}-\frac{C_{j,t+1}P_{j,t+1}}{C_{j,t}}=-\beta\left(1-\delta_{j,M}\right)P_{j,t+1}\quad\text{for all } j \text{ and } t. \tag{A17}$$

Combining the production function given by Equation (A1), the budget constraint given by Equation (5), the expression for $E_{j,t}$ given in Equation (A6), the expressions for $p_{j,t}$ for each t from Equation (11), and the equations for the trade MRTs $P_{j,t}$ and $\Pi_{j,t}$ given by Equations (9) and (10), respectively, with the two first order conditions for $K_{j,t+1}$ and $M_{j,t+1}$ as given by Equations (A14) and (A16), respectively, we end up with the following system:

$$Y_{j,t}=p_{j,t}A_{j,t}\left(L_{j,t}^{1-\alpha_j}K_{j,t}^{\alpha_j}\right)^{1-\phi_j}\left(\prod_{i=1}^{N}\left(\max\{1,\omega_{ij,t}M_{i,t}\}\right)^{\eta_i}\right)^{\phi_j}\quad\text{for all } j \text{ and } t, \tag{A18}$$

$$E_{j,t}=P_{j,t}C_{j,t}+P_{j,t}\left(K_{j,t+1}-\left(1-\delta_{j,K}\right)K_{j,t}\right)+P_{j,t}\left(M_{j,t+1}-\left(1-\delta_{j,M}\right)M_{j,t}\right)\quad\text{for all } j \text{ and } t, \tag{A19}$$

$$E_{j,t}=Y_{j,t}+\eta_j\sum_{\substack{i\neq j,\\ \omega_{ji,t}M_{j,t}>1}}\phi_iY_{i,t}-\phi_jY_{j,t}\sum_{\substack{i\neq j,\\ \omega_{ij,t}M_{i,t}>1}}\eta_i\quad\text{for all } j \text{ and } t, \tag{A20}$$

$$p_{j,t}=\frac{\left(Y_{j,t}/Y_t\right)^{\frac{1}{1-\sigma}}}{\gamma_j\Pi_{j,t}}\quad\text{for all } j \text{ and } t, \tag{A21}$$

$$Y_t=\sum_{j=1}^{N}Y_{j,t}\quad\text{for all } t, \tag{A22}$$

$$P_{j,t}^{1-\sigma} = \sum_{i=1}^{N} \left(\frac{t_{ij,t}}{\Pi_{i,t}}\right)^{1-\sigma} \frac{Y_{i,t}}{Y_t} \quad \text{for all } j \text{ and } t, \tag{A23}$$

$$\Pi_{i,t}^{1-\sigma} = \sum_{j=1}^{N} \left(\frac{t_{ij,t}}{P_{j,t}}\right)^{1-\sigma} \frac{E_{j,t}}{Y_t} \quad \text{for all } i \text{ and } t, \tag{A24}$$

$$\beta \left(1 - \phi_j \sum_{\substack{i \neq j, \\ \omega_{ij,t+1} M_{i,t+1} > 1}} \eta_i \right) \alpha_j (1-\phi_j) \frac{Y_{j,t+1}}{K_{j,t+1}} - \frac{C_{j,t+1} P_{j,t+1}}{C_{j,t}} = \beta \left(\delta_{j,K} - 1\right) P_{j,t+1} \quad \text{for all } j \text{ and } t. \tag{A25}$$

$$\beta \left(1 - \phi_j \sum_{\substack{i \neq j, \\ \omega_{ij,t+1} M_{i,t+1} > 1}} \eta_i \right) \frac{\eta_j \phi_j Y_{j,t+1}}{M_{j,t+1}} + \beta \eta_j \sum_{\substack{i \neq j, \\ \omega_{ji,t+1} M_{j,t+1} > 1}} \frac{\eta_j \phi_i^2 Y_{i,t+1}}{M_{j,t+1}} - \frac{C_{j,t+1} P_{j,t+1}}{C_{j,t}} = \beta \left(\delta_{j,M} - 1\right) P_{j,t+1} \quad \text{for all } j \text{ and } t. \tag{A26}$$

This is a system of $(8 \times N + 1) \times T$ equations in the $(8 \times N + 1) \times T$ unknowns $C_{j,t}$, $K_{j,t}$, $M_{j,t}$, $Y_{j,t}$, Y_t, $p_{j,t}$, $P_{j,t}$, $\Pi_{j,t}$, $E_{j,t}$ and given parameters and exogenous variables $A_{j,t}$, $\omega_{ij,t}$, $L_{j,t}$, α_j, β, ϕ_j, η_j, γ_j, σ, $t_{ij,t}$, $\delta_{j,K}$, and $\delta_{j,M}$.

A.2 Derivation of the Steady-State

In steady-state, values for $t+1$ and t have to be equal. Hence, we can express physical and technology capital as:

$$K_j = \frac{\Omega_j}{\delta_{j,K}}, \tag{A27}$$

$$M_j = \frac{\chi_j}{\delta_{j,M}}. \tag{A28}$$

Further, we can drop the time index for all variables. Let us first drop time indices in the first-order condition for physical capital as given in Equation (A25):

$$\beta \left(1 - \phi_j \sum_{\substack{i \neq j, \\ \omega_{ij} M_i > 1}} \eta_i \right) \alpha_j (1 - \phi_j) \frac{Y_j}{K_j} - \frac{C_j P_j}{C_j} =$$

$$\beta \left(\delta_{j,K} - 1 \right) P_j \quad \text{for all } j. \Rightarrow$$

$$\beta \left(1 - \phi_j \sum_{\substack{i \neq j, \\ \omega_{ij} M_i > 1}} \eta_i \right) \alpha_j (1 - \phi_j) \frac{Y_j}{P_j K_j} - 1 =$$

$$\beta \left(\delta_{j,K} - 1 \right) \quad \text{for all } j. \Rightarrow$$

$$\beta \left(1 - \phi_j \sum_{\substack{i \neq j, \\ \omega_{ij} M_i > 1}} \eta_i \right) \frac{\alpha_j (1 - \phi_j)}{(1 - \beta + \beta \delta_{j,K})} \frac{Y_j}{P_j} =$$

$$K_j \quad \text{for all } j.$$

Let us next drop time indices in the first-order condition for technology capital as given in Equation (A26):

$$\beta\left(1-\phi_j\sum_{\substack{i\neq j,\\ \omega_{ij}M_i>1}}\eta_i\right)\frac{\eta_j\phi_jY_j}{M_j}+\beta\eta_j\sum_{\substack{i\neq j,\\ \omega_{ji}M_j>1}}\frac{\eta_j\phi_i^2Y_i}{M_j}-\frac{C_jP_j}{C_j}=\beta\left(\delta_{j,M}-1\right)P_j\quad\text{for all } j\Rightarrow$$

$$\beta\left(1-\phi_j\sum_{\substack{i\neq j,\\ \omega_{ij}M_i>1}}\eta_i\right)\frac{\eta_j\phi_jY_j}{P_jM_j}+\beta\eta_j\sum_{\substack{i\neq j,\\ \omega_{ji}M_j>1}}\frac{\eta_j\phi_i^2Y_i}{P_jM_j}-1=\beta\left(\delta_{j,M}-1\right)\quad\text{for all } j\Rightarrow$$

$$\frac{\beta\eta_j}{1-\beta+\beta\delta_{j,M}}\left(\left(1-\phi_j\sum_{\substack{i\neq j,\\ \omega_{ij}M_i>1}}\eta_i\right)\frac{\phi_jY_j}{P_j}+\sum_{\substack{i\neq j,\\ \omega_{ji}M_j>1}}\frac{\eta_j\phi_i^2Y_i}{P_j}\right)=M_j\quad\text{for all } j.$$

Hence, the equation system given by Equations (A18)-(A26) simplifies to:

$$Y_j = p_j A_j \left(L_j^{1-\alpha_j} K_j^{\alpha_j}\right)^{1-\phi_j} \left(\prod_{i=1}^{N} (\max\{1, \omega_{ij} M_i\})^{\eta_i}\right)^{\phi_j} \quad \text{for all } j, \tag{A29}$$

$$E_j = P_j C_j + P_j \delta_{j,K} K_j + P_j \delta_{j,M} M_j \quad \text{for all } j, \tag{A30}$$

$$E_j = Y_j + \eta_j \sum_{\substack{i \neq j, \\ \omega_{ji} M_j > 1}} \phi_i Y_i - \phi_j Y_j \sum_{\substack{i \neq j, \\ \omega_{ij} M_i > 1}} \eta_i \quad \text{for all } j, \tag{A31}$$

$$p_j = \frac{(Y_j/Y)^{\frac{1}{1-\sigma}}}{\gamma_j \Pi_j} \quad \text{for all } j, \tag{A32}$$

$$Y = \sum_{j=1}^{N} Y_j, \tag{A33}$$

$$P_j^{1-\sigma} = \sum_{i=1}^{N} \left(\frac{t_{ij}}{\Pi_i}\right)^{1-\sigma} \frac{Y_i}{Y} \quad \text{for all } j, \tag{A34}$$

$$\Pi_i^{1-\sigma} = \sum_{j=1}^{N} \left(\frac{t_{ij}}{P_j}\right)^{1-\sigma} \frac{E_j}{Y} \quad \text{for all } i, \tag{A35}$$

$$K_j = \beta \left(1 - \phi_j \sum_{\substack{i \neq j, \\ \omega_{ij} M_i > 1}} \eta_i\right) \frac{\alpha_j (1 - \phi_j)}{(1 - \beta + \beta \delta_{j,K})} \frac{Y_j}{P_j} \quad \text{for all } j, \tag{A36}$$

$$M_j = \frac{\beta \eta_j}{1 - \beta + \beta \delta_{j,M}} \left(\left(1 - \phi_j \sum_{\substack{i \neq j, \\ \omega_{ij} M_i > 1}} \eta_i\right) \frac{\phi_j Y_j}{P_j} + \sum_{\substack{i \neq j, \\ \omega_{ji} M_j > 1}} \frac{\eta_j \phi_i^2 Y_i}{P_j} \right) \quad \text{for all } j. \tag{A37}$$

Note that trade flows in steady-state are then given by $X_{ij} = \frac{Y_i E_j}{Y} \left(\frac{t_{ij}}{\Pi_i P_j}\right)^{1-\sigma}$.

A.3 Derivation of FDI Gravity Equation

The steady state system above yields a convenient gravity representation of FDI that is remarkably similar to the familiar trade gravity system. To obtain it, recall the (steady-state) definition of bilateral FDI stock:

$$FDI_{ij} \equiv \omega_{ij} M_i. \tag{A38}$$

Replacing M_i by the expression given in Equation (A37), we can write:

$$FDI_{ij} \equiv \omega_{ij} \frac{\beta \eta_i}{1-\beta+\beta\delta_{i,M}} \left(\left(1 - \phi_i \sum_{\substack{k \neq i, \\ \omega_{ki} M_k > 1}} \eta_k \right) \frac{\phi_i Y_i}{P_i} + \sum_{\substack{k \neq i, \\ \omega_{ik} M_i > 1}} \frac{\eta_i \phi_k^2 Y_k}{P_i} \right). \tag{A39}$$

Equation (A39) describes physical FDI stocks. To translate (A39) into a stock value FDI equation needed for estimation with data on FDI stock *values*, define the value of FDI from country i to country j as the product of the FDI stock times its value marginal product:

$$\begin{aligned} FDI_{ij}^{value} &\equiv FDI_{ij} \times \frac{\partial Y_j}{\partial M_i} \\ &= \omega_{ij} \frac{\beta \eta_i^2}{1-\beta+\beta\delta_{i,M}} \left(\left(1 - \phi_i \sum_{\substack{k \neq i, \\ \omega_{ki} M_k > 1}} \eta_k \right) \frac{\phi_i Y_i}{P_i} + \sum_{\substack{k \neq i, \\ \omega_{ik} M_i > 1}} \frac{\eta_i \phi_k^2 Y_k}{P_i} \right) \frac{\phi_j Y_j}{M_i}. \end{aligned} \tag{A40}$$

Assuming a common production share of FDI across countries, $E_i = Y_i + \eta_i \phi \sum_{\substack{j \neq i, \\ \omega_{ij} M_i > 1}} Y_j - \phi Y_i \sum_{\substack{j \neq i, \\ \omega_{ji} M_j > 1}} \eta_j$ and using the steady-state solution for technology capital M_i from Equation (A37), we can write:

$$M_i = \frac{\beta \phi \eta_i}{1-\beta+\beta\delta_{i,M}} \frac{E_i}{P_i}. \tag{A41}$$

Substitute for M_i in Equation (A38) to obtain:

$$FDI_{ij} = \omega_{ij} \frac{\beta \phi \eta_i}{1-\beta+\beta\delta_{i,M}} \frac{E_i}{P_i}. \tag{A42}$$

Translating (A42) into a stock value FDI equation needed for estimation we again multiply with the value marginal product:

$$FDI_{ij}^{value} \equiv FDI_{ij} \times \frac{\partial Y_j}{\partial M_i} = \omega_{ij} \frac{\beta \phi \eta_i}{1 - \beta + \beta \delta_{i,M}} \frac{E_i}{P_i} \phi \eta_i \frac{Y_j}{M_i} = \frac{\beta \phi^2 \eta_i^2}{1 - \beta + \beta \delta_{i,M}} \omega_{ij} \frac{E_i}{P_i} \frac{Y_j}{M_i}. \quad \text{(A43)}$$

Combine Equation (A43) with the definitions of the multilateral resistance terms P_j and Π_j given by Equations (A34) and (A35), respectively, to obtain the following FDI gravity system:

$$FDI_{ij}^{value} = \frac{\beta \phi^2 \eta_i^2}{1 - \beta + \beta \delta_{i,M}} \omega_{ij} \frac{E_i}{P_i} \frac{Y_j}{M_i}, \quad \text{(A44)}$$

$$P_i = \left[\sum_{j=1}^{N} \left(\frac{t_{ji}}{\Pi_j} \right)^{1-\sigma} \frac{Y_j}{Y} \right]^{\frac{1}{1-\sigma}}, \quad \text{(A45)}$$

$$\Pi_j = \left[\sum_{i=1}^{N} \left(\frac{t_{ji}}{P_i} \right)^{1-\sigma} \frac{E_i}{Y} \right]^{\frac{1}{1-\sigma}}. \quad \text{(A46)}$$