ANTICIPATED TARIFF CHANGES,
PRODUCTIVITY DISRUPTION,
AND THE FIRM-LEVEL FDI DECISION

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Abstract

I develop a dynamic sector-specific model of the firm-level horizontal FDI decision when faced with an anticipated tariff increase. I look at three different strategies: continue to supply the market through exports, supply the market through the acquisition of a domestic firm, or supply the market through greenfield FDI. Through a series of illustrative simulations I show that a firm's FDI decision is based on the anticipated implementation date and expected duration of the tariff increase, market share, relative wage rate, expected fixed cost of FDI, and the extent of productivity disruption to acquirable firms.

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1 Introduction

Foreign direct investment (FDI) can be classified into two main types: vertical and horizontal. Vertical FDI refers to the geographic fragmentation of stages in the global value chain. This type of FDI is used to take advantage of international factor endowment and costs differences. Horizontal FDI refers to the establishment of all production in the target market to avoid costs to cross-border trade. In this paper I focus on horizontal FDI although both types of FDI are impacted by trade policy. Yeaple (2003) shows that vertical FDI is more likely to occur in countries where trade costs are low, and horizontal FDI is more likely to occur where trade costs are high. Lower trade costs makes intra-firm international trade of products at different stages of the global value chain easier, allowing firms to take advantage of heterogeneous global factor endowments. Higher trade costs push firms to invest in production in the target markets to avoid the cross-border trade barriers.

In a review of developments in the FDI literature, Riker and Wickramarachi (2020) points out the trend toward firm-level data in the econometric literature. In this paper I develop a dynamic industry specific Bertrand differentiated products model that is set up to use firm-level data to assess the impact of trade policies on horizontal FDI decisions. Horizontal FDI can come in different forms including mergers, acquisitions, and greenfield investment. The firm-level decisions to continue to export or supply through different types of FDI depends on multiple factors which include the fixed cost of FDI, the anticipated implementation date and expected duration of trade policy changes, relative wage rates, and productivity disruptions.[1]

Tekin-Koru (2009) outlines a theoretical model of the firm-level decision to supply a market through different types of FDI based on factors such as trade costs, market concentration, and technology transfer. The dynamic model I develop in this paper is based off the

[1] Productivity disruptions refers to the decrease in productivity of acquired firms following acquisition and is discussed further in Section 2.

Tekin-Koru (2009) static model of FDI decisions and the partial equilibrium models of FDI in Riker (2019) and Riker and Schreiber (2019).

An important part of firm-level decision making is the fixed cost of FDI that a firm needs to pay to enter the target market. Helpman, Melitz and Yeaple (2004) assumes that the fixed cost of FDI is country-specific and common to all industries and therefore absorbed in the country fixed effects. This assumption simplifies econometric analysis, but does not work in an industry-specific structural model. I build on the method developed in Riker and Schreiber (2019) that calculates the upper and lower bounds of the fixed cost of FDI to construct a probability distribution of possible fixed costs firms could face.

The model I present in this paper differs from previous structural models of FDI in the literature in a few ways. First, it is a dynamic multi-period model that captures the effects of anticipated trade policy changes and productivity disruption on firm-level FDI decisions. I show that these are two important factors that cannot be adequately considered in a static framework. Second, this model includes a calibrated fixed cost of FDI—an important factor that firms consider when making an FDI decision that is typically difficult to quantify. Third, it is set up to use firm-level data and has minimal data requirements. This model is especially well suited to analyze situations where firms in an FDI intensive industry are faced with staged trade policy changes. A recent example of such scenario is the staging of the Rules of Origin requirement in the automotive manufacturing industry included in the United States-Mexico-Canada Agreement.

In this paper I develop the theoretical framework of the model and through a series of illustrative simulations show that the timing and expected duration of trade policy changes has an a heterogeneous impact on the firm-level horizontal FDI decision across industries.

In Section 2 I outline the theoretical model and equations. In Section 3 I calibrate the model parameters and fixed costs of FDI using the methods first laid out in Riker and Schreiber (2019). Then I run a series of illustrative simulations to show how the model works in Section 4. I provide discussion and conclude in Section 5.

2 Theoretical Framework

The sector-specific model has two countries and five firms: three geographically located in the domestic market and two located in the foreign country supplying the domestic market.[2][3] Each firm in this Bertrand style model produces slightly differentiated products. Equations (1)–(3) represent the demand for the products produced by the three domestically located firms and equations (4) and (5) represent the demand for products imported by the two foreign firms. Demand for each product has the constant elasticity of substitution (CES) form with elasticity of substitution σ and total industry price elasticity of demand η.

$$q_{D1,t} = k\ b_{D1}\ (P_t)^{\eta} \left(\frac{p_{D1,t}}{P_t}\right)^{-\sigma} \tag{1}$$

$$q_{D2,t} = k\ b_{D2}\ (P_t)^{\eta} \left(\frac{p_{D2,t}}{P_t}\right)^{-\sigma} \tag{2}$$

$$q_{D3,t} = k\ b_{D3}\ (P_t)^{\eta} \left(\frac{p_{D3,t}}{P_t}\right)^{-\sigma} \tag{3}$$

$$q_{F1,t} = k\ b_{F1}\ (P_t)^{\eta} \left(\frac{p_{F1,t}\tau_{F1,t}}{P_t}\right)^{-\sigma} \tag{4}$$

$$q_{F2,t} = k\ b_{F2}\ (P_t)^{\eta} \left(\frac{p_{F2,t}\tau_{F2,t}}{P_t}\right)^{-\sigma} \tag{5}$$

Let $j \in \{D1, D2, D3, F1, F2\}$, $p_{j,t}$ is the price of firm j's product in period t, b_j is the calibrated preference parameter for the product produced by firm j, $\tau_{j,t}$ is the trade cost factor in period t, k is a demand parameter equal to total expenditure in the industry, and

[2]For the rest of this paper the firms supplying FDI to the target market will be referred to as foreign firms and firms geographically located in the target market will be referred to as domestic firms.

[3]I use a five firm model to meet the basic requirement that a minimum of one foreign firm needs to be engaged in each type of supply strategy to calibrate the fixed costs of FDI. This is discussed further in Section 3.2.

P_t is the CES price index in period t defined in equation (6).

$$P_t = \left[b_{D1} \left(p_{D1,t}\right)^{1-\sigma} + b_{D2} \left(p_{D2,t}\right)^{1-\sigma} + b_{D3} \left(p_{D3,t}\right)^{1-\sigma} + b_{F1} \left(p_{F1,t}\tau_t\right)^{1-\sigma} + b_{F2} \left(p_{F2,t}\tau_t\right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \tag{6}$$

In the initial equilibrium firm $F1$ only supplies the domestic market through imports, $D1$ is a domestic firm with no foreign ownership, $F2$ owns firm $D2$ and jointly determines prices, and firm $D3$ is the greenfield transplant production of a foreign firm. I assume firm $D3$ is the transplant production established through greenfield FDI supplied from the same foreign country where firm $F1$ and $F2$ are located to the domestic market. Equations (7)–(10) represent the variable profits of each firm j with a marginal cost of production m_j in the initial period $t = 0$.

$$\pi_{D1,t} = (p_{D1,t} - m_{D1})\, q_{D1,t}, \quad \forall\, t = 0 \tag{7}$$

$$\pi_{D3,t} = (p_{D3,t} - m_{D3})\, q_{D3,t}, \quad \forall\, t = 0 \tag{8}$$

$$\pi_{F1,t} = (p_{F1,t} - m_{F1})\, q_{F1,t}, \quad \forall\, t = 0 \tag{9}$$

$$\pi_{F2,t} + \pi_{D2,t} = (p_{F2,t} - m_{F2})\, q_{F2,t} + (p_{D2,t} - m_{D2})\, q_{D2,t}, \quad \forall\, t = 0 \tag{10}$$

The profit functions depend on the quantities $q_{j,t}$ that each respective firm produces. These quantities are influenced by the firms' pricing decisions and resulting CES price index P_t. Which is an important reason that firm $F2$ setting prices for themselves and firm $D2$ to maximize their joint profit function matters.

In this model, firm $F1$ is the firm making the FDI decision. When faced with a future scheduled tariff increase they have three options: they can continue to supply the domestic market through exports, acquire a domestic firm to supply the domestic market, or transplant production into the domestic market through greenfield FDI. I assume that the investment opportunities are only available to firm F1, the other firms cannot invest to deviate from their current strategies, but can still adjust their production and prices as normal. Firm $F1$ chooses the strategy that maximizes the present discounted value of profits based on the anticipated implementation date and expected duration of the tariff increase. In the initial period zero ($t = 0$), firm $F1$ is made aware of a future tariff increase and each strategy has the same initial profit function in (9). There is no FDI in this period and the market remains in the initial equilibrium.

In period one, the firm makes a discrete choice to engage in one of the three options. In the model, once the firm makes a decision on which strategy they plan to use in period one, they cannot change their strategy in future periods. If the firm chooses to continue exporting, they will continue to receive the present discounted value of the profit function (9) in all future periods, but paying the higher variable cost from the tariff increase and setting their new Nash equilibrium prices. If the firm chooses the acquisition strategy, they pay the full fixed cost of acquisition FDI (C_A) in period one, but do not begin joint determining prices or receiving profits from the acquired firm, $D1$, until period two. This delay in receiving profits captures the time component of the acquisition process. Acquisitions are not instantaneous and often times involve receiving shareholder approval, borrowing of capital, and other legal processes. I assume that the fixed cost of greenfield FDI is paid over four periods—I consider this the time to build a new production facility.[4] If the firm chooses the greenfield strategy, they will pay a quarter of the fixed cost of greenfield FDI ($\frac{C_G}{4}$) in periods one through four and will not supply the domestic market from the transplant facility until they finish paying the fixed cost.[5] Equation (11) is the profit function of the acquisition strategy of firm $F1$ in period one and equation (12) is the profit function of the greenfield strategy for firm $F1$ in

[4]This is an adjustable assumption that can be changed to fit the industry, although I do not adjust it in this paper.

[5]The fixed costs of FDI, C_A and C_G, are calibrated in Section 3.2.

periods one through four.

$$\pi^A_{F1,t} = (p_{F1,t} - m_{F1,t})\ q_{F1,t}\ \ -\ \ C_A, \quad \forall\ t = 1 \tag{11}$$

$$\pi^G_{F1,t} = (p_{F1,t} - m_{F1,t})\ q_{F1,t}\ \ -\ \ \frac{C_G}{4}, \quad \forall\ t = 1, 2, 3, 4 \tag{12}$$

Superscripts A and G stand for acquisition and greenfield respectively, and identify the strategy that the profit functions belong to.

If firm $F1$ chooses the acquisition strategy, in all periods following period one they receive the profit function in equation (13).

$$\pi^A_{F1,t} = (p_{F1,t} - m_{F1,t})\ q_{F1,t}\ \ +\ \ (p_{D1,t} - \gamma_t m_{D1,t})\ q_{D1,t}, \quad \forall\ t = 2, ..., N \tag{13}$$

$\gamma_t >= 1$, is a productivity disruption parameter that behaves similarly to the concept of technology harmonization in the Tekin-Koru (2009) model. This productivity disruption parameter decreases in each period following the acquisition. This post-acquisition productivity disruption accounts for the decreased productivity that comes with the transitioning of ownership and possible management turnover, rebranding, and technology transfer. For industries with less differentiated products and easily transferable technology, the productivity disruption will be small and dissipate quicker. For industries with more differentiated products and complex technology and production processes, the productivity disruption will be larger and take longer to dissipate.

If firm $F1$ chooses the greenfield strategy, they receive the profit function in equation (14) starting in period five and each period following. With greenfield FDI the firm is no longer subject to any initial trade costs and avoids the anticipated tariff increase.

$$\pi^G_{F1,t} = (p_{F1,t} - \omega m_{F1,t})\ q_{F1,t}, \quad \forall\ t = 5, ..., N \tag{14}$$

ω is the ratio of wages in the domestic country to the wages in the foreign country which is assumed to remain constant across periods.

In each period, each of the five firms simultaneously and independently set prices, $p_{j,t}$, in order to maximize their profits, $\pi_{j,t}$—defined in equations (7)–(14) described above—taking the product preference parameters b_j as exogenous, and subject to the following constraints: firm $F1$ is the only firm with investment options, firm $F1$ must choose and implement an investment strategy in period one and cannot deviate from the chosen strategy in future periods, and each period is treated as a separate independent game—that is, firms cannot cooperate or be penalized on pricing across periods.

In the initial period, each firm sets prices according to the first order conditions (FOCs) in equations (15)–(19). The FOCs are found by taking the partial derivative of each firm's profit function with respect to their own prices, setting the resulting partial derivatives equal to zero and solving for the respective prices.[6] For firm $F2$, who owns $D2$ and jointly determines prices, the FOCs (16) and (19) are found by taking the derivative of equation (10) with respect to p_{D2} and p_{F2} respectively.

$$
\begin{aligned}
p_{D1,t} &= \big(p_{D1,t} - m_{D1}\big)\big(\sigma - (\eta+\sigma)\ \mu_{D1,t}\big) && (15)\\
p_{D2,t} &= \big(p_{D2,t} - m_{D2}\big)\big(\sigma - (\eta+\sigma)\ \mu_{D2,t}\big) - \left[\frac{(p_{F2,t} - m_{F2})(\eta+\sigma)(\frac{p_{D2,t}}{p_{F2}\ \tau_t})^{\sigma}\mu_{D2,t}\ b_{F2}}{b_{D2}}\right] && (16)\\
p_{D3,t} &= \big(p_{D3,t} - m_{D3}\big)\big(\sigma - (\eta+\sigma)\ \mu_{D3,t}\big) && (17)\\
p_{F1,t} &= \big(p_{F1,t} - m_{F1}\big)\big(\sigma - (\eta+\sigma)\ \mu_{F1,t}\big) && (18)\\
p_{F2,t} &= \big(p_{F2,t} - m_{F2}\big)\big(\sigma - (\eta+\sigma)\ \mu_{F2,t}\big) - \left[\frac{(p_{D2,t} - m_{D2})(\eta+\sigma)(\frac{p_{F2}\tau_t}{p_{D2,t}})^{\sigma}\mu_{F2,t}\ b_{D2}}{b_{F2}}\right] && (19)
\end{aligned}
$$

$\mu_{j,t}$ is the market share of firm j in period t from equation (20).

[6]In the initial period the FOCs are found by taking the partial derivatives of equations (7)–(10) with respect to the respective firm's prices.

$$\mu_{j,t} = b_j \Big(\frac{p_{j,t}\ \tau_{j,t}}{P_t}\Big)^{1-\sigma} \tag{20}$$

If the firm chooses to continue to export to the domestic market, the FOCs in every period are the same as this first set. If firm $F1$ chooses to acquire the domestic firm $D1$, the first set of FOCs are the same for periods one and two, but switch to the second set of equations (21)–(25) for all the following periods.[7]

$$p_{D1,t} = \big(p_{D1,t} - \gamma_t m_{D1}\big)\big(\sigma - (\eta+\sigma)\mu_{D1,t}\big) - \Big[\frac{(p_{F1,t} - m_{F1})(\eta+\sigma)(\frac{p_{D1,t}}{p_{F1}\ \tau_t})^{\sigma}\mu_{D1,t}\ b_{F1}}{b_{D1}}\Big] \tag{21}$$

$$p_{D2,t} = \big(p_{D2,t} - m_{D2}\big)\big(\sigma - (\eta+\sigma)\mu_{D2,t}\big) - \Big[\frac{(p_{F2,t} - m_{F2})(\eta+\sigma)(\frac{p_{D2,t}}{p_{F2}\ \tau_t})^{\sigma}\mu_{D2,t}\ b_{F2}}{b_{D2}}\Big] \tag{22}$$

$$p_{D3,t} = \big(p_{D3,t} - m_{D3}\big)\big(\sigma - (\eta+\sigma)\ \mu_{D3,t}\big) \tag{23}$$

$$p_{F1,t} = \big(p_{F1,t} - m_{F1}\big)\big(\sigma - (\eta+\sigma)\mu_{F1,t}\big) - \Big[\frac{(p_{D1,t} - \gamma_t m_{D1})(\eta+\sigma)(\frac{p_{F1}\tau_t}{p_{D1,t}})^{\sigma}\mu_{F1,t}\ b_{D1}}{b_{F1}}\Big] \tag{24}$$

$$p_{F2,t} = \big(p_{F2,t} - m_{F2}\big)\big(\sigma - (\eta+\sigma)\mu_{F2,t}\big) - \Big[\frac{(p_{D2,t} - m_{D2})(\eta+\sigma)(\frac{p_{F2}\tau_t}{p_{D2,t}})^{\sigma}\mu_{F2,t}\ b_{D2}}{b_{F2}}\Big] \tag{25}$$

The last set of FOCs determine the profit maximizing prices when firm $F1$ sets up production in the domestic market through greenfield FDI. This set of FOCs in equations (26)–(30) determines prices in all periods after the firm finishes paying the full fixed cost of greenfield FDI in period four.[8]

[7] The FOCs in equations (21)–(25) are derived from equations (8), (10), and (13).

[8] The FOCs in equations (26)–(30) are derived from equations (7), (8), (10), and (14).

$$p_{D1,t} \;=\; \big(p_{D1,t} - m_{D1}\big)\big(\sigma - (\eta+\sigma)\ \mu_{D1,t}\big) \tag{26}$$

$$p_{D2,t} \;=\; \big(p_{D2,t} - m_{D2}\big)\big(\sigma - (\eta+\sigma)\ \mu_{D2,t}\big) \;-\; \Big[\frac{(p_{F2,t} - m_{F2})(\eta+\sigma)(\frac{p_{D2,t}}{p_{F2}\ \tau_t})^{\sigma}\mu_{D2,t}\ b_{F2}}{b_{D2}}\Big] \tag{27}$$

$$p_{D3,t} \;=\; \big(p_{D3,t} - m_{D3}\big)\big(\sigma - (\eta+\sigma)\ \mu_{D3,t}\big) \tag{28}$$

$$p_{F1,t} \;=\; \big(p_{F1,t} - \omega m_{F1}\big)\big(\sigma - (\eta+\sigma)\ \mu_{F1,t}\big) \tag{29}$$

$$p_{F2,t} \;=\; \big(p_{F2,t} - m_{F2}\big)\big(\sigma - (\eta+\sigma)\ \mu_{F2,t}\big) \;-\; \Big[\frac{(p_{D2,t} - m_{D2})(\eta+\sigma)(\frac{p_{F2}\tau_t}{p_{D2,t}})^{\sigma}\mu_{F2,t}\ b_{D2}}{b_{F2}}\Big] \tag{30}$$

Firm $F1$ will choose the optimal strategy to maximize the present discounted value of total profits according to equation (31). Where N is the total number of periods.

$$\Pi_{F1} \;=\; \max_{k\in\{E,A,G\}}\Big[\sum_{t=0}^{N}\beta^t(\pi^E_{F1,t}),\ \sum_{t=0}^{N}\beta^t(\pi^A_{F1,t}),\ \sum_{t=0}^{N}\beta^t(\pi^G_{F1,t})\Big] \tag{31}$$

$\beta^t < 1$, is the discount factor, and superscript E stands for export and signifies the strategy that the profit function belongs to.

3 Model Calibration

3.1 Parameter Calibration

I start with the initial expenditure on products for each firm. In the initial equilibrium ($t = 0$), I set all prices equal to one and calibrate the demand parameter k and product preference parameters b_j according to equations (32) and (33) respectively.

$$k = \frac{q_{D1,t=0}}{\left(P_{t=0}\right)^{\eta}\left(\frac{p_{D1,t=0}}{P_{t=0}}\right)^{-\sigma}} \tag{32}$$

$$b_j = \left(\frac{V_{j,t=0}}{V_{D1,t=0}}\right)\left(\frac{p_{j,t=0}\tau_{j,t=0}}{p_{D1,t=0}}\right)^{\sigma-1} \tag{33}$$

$V_{j,t=0}$ is the initial domestic market expenditure on products supplied by firm j.

After calibrating the product preference parameter and demand parameter I calibrate the constant marginal cost of each firm by setting prices equal to one and solving for m_j using the initial set of FOCs in equations (15)–(19).

3.2 Fixed Cost of FDI Calibration

There is a fixed cost of FDI that firms have to pay in order to enter the domestic market through acquisition or greenfield development. This fixed cost can be difficult to quantify and FDI literature handles this issue in different ways. Grossman, Helpman and Szeidl (2006) focuses on the role industry specific fixed costs play in firm-level FDI decisions, but do not attempt to quantify it. The econometric literature such as Helpman et al. (2004) can make assumptions that allow the fixed cost of FDI to be absorbed in the country fixed effects. Ramondo and Rodríguez-Clare (2013) build a structural general equilibrium model of vertical and horizontal FDI that does not include fixed costs.

Riker and Schreiber (2019) use a two-country industry-specific model with two firms to calculate a lower and upper bound of the fixed cost of FDI. They show that for a foreign firm that supplies the domestic market through exports, the variable profits from exporting minus the fixed cost of exporting must be greater than the variable profits of FDI in the domestic market minus the fixed cost of FDI. The reverse must be true for a firm who supplies the domestic market through FDI. Knowing that these conditions must be true and assuming the fixed cost of FDI and exporting is the same for each firm, the lower bound of the fixed cost of FDI is equal to the difference between their variable profits if they deviate to supplying through FDI—while the second firm remains in the initial equilibrium—and their initial variable profits from exporting. The upper bound is the difference between the initial variable profits of the firm supplying through FDI in the initial equilibrium and their variable profits if they deviate to exporting while the other firm continues to export.

Using this same methodology applied to my five firm model, I am able to calibrate an upper and lower bound for both greenfield and acquisition FDI.[9] I assume a uniform distribution of possible fixed costs between these upper and lower bounds. Firm $F1$ bases their FDI decision on the expected fixed cost, C, from this distribution. Starting with the initial equilibrium I calculate variable profits using the parameters calibrated in Section 3.1, equations (7)–(10), and initial prices: $p_{D1} = p_{D2} = p_{D3} = p_{F1} = p_{F2} = 1$.

To calibrate the fixed cost distribution of greenfield FDI, I deviate firm $F1$ to supplying the domestic market through greenfield FDI. The new deviation variable profits, π^{*G}_{F1}, are represented by equation (34), where p^{*G}_{F1} are the deviation prices and all other prices remain at the initial equilibrium prices. The superscript * indicates the deviation value.

$$\begin{aligned}\pi^{*G}_{F1} \;=\; & (p^{*G}_{F1} - \omega m_{F1}) k b_{F1} \\ & ([(p_{D1})^{1-\sigma} + b_{D2}(p_{D2})^{1-\sigma} + b_{D3}(p_{D3})^{1-\sigma} + b_{F1}\,(p^{*G}_{F1})^{1-\sigma} + b_{F2}(p_{F2}\tau)^{1-\sigma}]^{\frac{1}{1-\sigma}})^{\eta} \\ & \left(\frac{p^{*G}_{F1}}{[(p_{D1})^{1-\sigma} + b_{D2}(p_{D2})^{1-\sigma} + b_{D3}(p_{D3})^{1-\sigma} + b_{F1}(p^{*G}_{F1})^{1-\sigma} + b_{F2}(p_{F2}\tau)^{1-\sigma}]^{\frac{1}{1-\sigma}}}\right)^{-\sigma}\end{aligned} \tag{34}$$

Firm $D3$'s deviation variable profits by switching from greenfield FDI back to exporting are

[9] This method of calibrating the fixed costs of FDI requires an industry where there is at least one foreign firm supplying the domestic market through exports and one supplying through FDI for each type of FDI in the model. Assuming the fixed cost of FDI is specific to a country-pair, those foreign firms must be supplying the domestic market from the same country.

represented by equation (35) with deviation price p^{*G}_{D3}.

$$\begin{aligned}
\pi^{*G}_{D3} &= (p^{*G}_{D3} - (\frac{1}{\omega})m_{D3})kb_{D3} \\
&([(p_{D1})^{1-\sigma} + b_{D2}(p_{D2})^{1-\sigma} + b_{D3}(p^{*G}_{D3}\tau)^{1-\sigma} + b_{F1}\ (p_{F1}\tau)^{1-\sigma} + b_{F2}(p_{F2}\tau)^{1-\sigma}]^{\frac{1}{1-\sigma}})^{\eta} \\
&\Big(\frac{p^{*G}_{D3}\tau}{[(p_{D1})^{1-\sigma} + b_{D2}(p_{D2})^{1-\sigma} + b_{D3}(p^{*G}_{D3}\tau)^{1-\sigma} + b_{F1}(p_{F1}\tau)^{1-\sigma} + b_{F2}(p_{F2}\tau)^{1-\sigma}]^{\frac{1}{1-\sigma}}}\Big)^{-\sigma}
\end{aligned} \tag{35}$$

The deviation prices are determined by the FOCs in equation (36).

$$0 = \frac{\partial \pi_{D1}}{\partial p_{D1}} = \frac{\partial(\pi_{D2} + \pi_{F2})}{\partial p_{D2}} = \frac{\partial \pi^{*G}_{D3}}{\partial p^{*G}_{D3}} = \frac{\partial \pi^{*G}_{F1}}{\partial p^{*G}_{F1}} = \frac{\partial(\pi_{F2} + \pi_{D2})}{\partial p_{F2}} \tag{36}$$

To calibrate the fixed cost distribution of acquisition FDI, I repeat the same process except $F1$ deviates to owning firm $D1$, firm $F2$ deviates to exporting, and firm $D2$ returns to being a domestic firm that sets their own prices. The new deviation variable profit functions for the firms are represented by equations (37)–(39).

$$\begin{aligned}
\pi^{*A}_{F1} + \pi^{*A}_{D1} &= (p^{*A}_{F1} - m_{F1})kb_{F1} \\
&([(p^{*A}_{D1})^{1-\sigma} + b_{D2}(p_{D2})^{1-\sigma} + b_{D3}(p_{D3})^{1-\sigma} + b_{F1}\ (p^{*A}_{F1}\tau)^{1-\sigma} + b_{F2}(p_{F2}\tau)^{1-\sigma}]^{\frac{1}{1-\sigma}})^{\eta} \\
&\Big(\frac{p^{*A}_{F1}\tau}{[(p^{*A}_{D1})^{1-\sigma} + b_{D2}(p_{D2})^{1-\sigma} + b_{D3}(p_{D3})^{1-\sigma} + b_{F1}(p^{*A}_{F1}\tau)^{1-\sigma} + b_{F2}(p_{F2}\tau)^{1-\sigma}]^{\frac{1}{1-\sigma}}}\Big)^{-\sigma} \\
&+\ (p^{*A}_{D1} - m_{D1})kb_{D1} \\
&([(p^{*A}_{D1})^{1-\sigma} + b_{D2}(p_{D2})^{1-\sigma} + b_{D3}(p_{D3})^{1-\sigma} + b_{F1}\ (p^{*A}_{F1}\tau)^{1-\sigma} + b_{F2}(p_{F2}\tau)^{1-\sigma}]^{\frac{1}{1-\sigma}})^{\eta} \\
&\Big(\frac{p^{*A}_{D1}}{[(p^{*A}_{D1})^{1-\sigma} + b_{D2}(p_{D2})^{1-\sigma} + b_{D3}(p_{D3})^{1-\sigma} + b_{F1}(p^{*A}_{F1}\tau)^{1-\sigma} + b_{F2}(p_{F2}\tau)^{1-\sigma}]^{\frac{1}{1-\sigma}}}\Big)^{-\sigma}
\end{aligned} \tag{37}$$

$$
\begin{aligned}
\pi^{*A}_{D2} &= (p^{*A}_{D2} - m_{D2})kb_{D2} \\
&([(p_{D1})^{1-\sigma} + b_{D2}(p^{*A}_{D2})^{1-\sigma} + b_{D3}(p_{D3})^{1-\sigma} + b_{F1}\ (p_{F1}\tau)^{1-\sigma} + b_{F2}(p^{*A}_{F2}\tau)^{1-\sigma}]^{\frac{1}{1-\sigma}})^{\eta} \\
&\left(\frac{p^{*A}_{D2}}{[(p_{D1})^{1-\sigma} + b_{D2}(p^{*A}_{D2})^{1-\sigma} + b_{D3}(p_{D3})^{1-\sigma} + b_{F1}(p_{F1}\tau)^{1-\sigma} + b_{F2}(p^{*A}_{F2}\tau)^{1-\sigma}]^{\frac{1}{1-\sigma}}}\right)^{-\sigma}
\end{aligned} \tag{38}
$$

$$
\begin{aligned}
\pi^{*A}_{F2} &= (p^{*A}_{F2} - m_{F2})kb_{F2} \\
&([(p_{D1})^{1-\sigma} + b_{D2}(p^{*A}_{D2})^{1-\sigma} + b_{D3}(p_{D3})^{1-\sigma} + b_{F1}\ (p_{F1}\tau)^{1-\sigma} + b_{F2}(p^{*A}_{F2}\tau)^{1-\sigma}]^{\frac{1}{1-\sigma}})^{\eta} \\
&\left(\frac{p^{*A}_{F2}\tau}{[(p_{D1})^{1-\sigma} + b_{D2}(p^{*A}_{D2})^{1-\sigma} + b_{D3}(p_{D3})^{1-\sigma} + b_{F1}(p_{F1}\tau)^{1-\sigma} + b_{F2}(p^{*A}_{F2}\tau)^{1-\sigma}]^{\frac{1}{1-\sigma}}}\right)^{-\sigma}
\end{aligned} \tag{39}
$$

The acquisition FDI deviation prices are determined by the FOCs in equation (40).

$$
0 = \frac{\partial(\pi^{*A}_{D1} + \pi^{*A}_{F1})}{\partial p^{*A}_{D1}} = \frac{\partial \pi^{*A}_{D2}}{\partial p^{*A}_{D2}} = \frac{\partial \pi_{D3}}{\partial p_{D3}} = \frac{\partial(\pi^{*A}_{F1} + \pi^{*A}_{D1})}{\partial p^{*A}_{F1}} = \frac{\partial \pi^{*A}_{F2}}{\partial p^{*A}_{F2}} \tag{40}
$$

Using the deviation prices for firm $F1$ and firm $F2$, I calculate the deviation variable profits and find the upper bounds (UB) and lower bounds (LB) of the FDI fixed cost distribution for each type of FDI.

$$
\pi^{*A}_{F1} - \pi_{F1} = C^{LB}_{A} \ < \ C_A \ < \ C^{UB}_{A} = \pi_{F2} - \pi^{*A}_{F2} \tag{41}
$$

$$
\pi^{*G}_{F1} - \pi_{F1} = C^{LB}_{G} \ < \ C_G \ < \ C^{UB}_{G} = \pi_{F2} - \pi^{*G}_{F2} \tag{42}
$$

I assume a uniform probability distribution of possible fixed costs between the upper and lower bounds. Firms base their FDI decisions on their ability to pay the expected fixed cost, $C_A = \frac{(C^{UB}_{A} - C^{LB}_{A})}{2}$ and $C_G = \frac{(C^{UB}_{G} - C^{LB}_{G})}{2}$, of the acquisition and greenfield strategies respectively.

The calibrated fixed cost of FDI includes costs such as permitting, construction of domestic facilities, cost of acquiring a domestic firm, and the cost of borrowing capital. Since I assume the interest on borrowed capital is included in the calibrated fixed costs I do not include any capital costs in the model. Additionally, I assume that the firms have unlimited access to capital, so they are able to borrow any amount of capital needed to pay the fixed cost of FDI.

4 Illustrative Simulations

In this section, I provide a series of illustrative simulations to show how the model works. This is a versatile model with many adjustable parameters and using illustrative simulations, I can show how industries and firms with different characteristics make different FDI decisions based on the anticipated start date and expected duration of a tariff increase. For these simulations I limit the number of periods to a maximum of ten, though the model can be made to look at any number of periods. Firm $F1$ is made aware of a future tariff increase in period zero and makes a discrete choice on a strategy that begins in period one. In each of the following simulations, I will look at all possible combinations of tariff implementation period and duration while adjusting the other parameters like relative wage rates, market shares and productivity disruption. I run four sets of simulations to show how these parameters impact firm-level FDI decision making in a dynamic framework. Table 1 provides the parameter inputs that will be used in each simulation.

The calibrated fixed costs of FDI in Table 1 show the large difference between the cost of acquisition and greenfield FDI. Consider these fixed costs in millions of U.S. dollars; for simulation (1) acquiring a firm in the domestic market has an expected fixed cost 75 million dollars compared to the 8.5 million dollar expected fixed cost of establishing a new production facility in the domestic market. I do not run a simulation in this paper that adjusts the initial trade cost factor, but an adjustment to this parameter would have a direct impact on the magnitude of the expected fixed costs. An increase in the initial trade cost factor increases the fixed cost of greenfield FDI.[10]

Table 1: Illustrative Simulation Inputs

	(1)	(2)	(3)	(4)
Expenditure on $D1$ (V_{D1})	200	200	200	200
Expenditure on $D2$ (V_{D2})	250	250	250	250
Expenditure on $D3$ (V_{D3})	200	200	200	200
Expenditure on $F1$ (V_{F1})	150	150	150	150
Expenditure on $F2$ (V_{F2})	100	100	100	100
Initial Productivity Disruption (γ)	2	2	**5**	**1**
Wage Ratio (ω)	1.1	1.1	1.1	1.1
Initial Trade Cost (τ_0)	1.05	1.05	1.05	1.05
New Trade Cost (τ_1)	1.3	**1.55**	1.3	1.55
Elasticity of Substitution (σ)	4	4	4	4
Total Industry Price Elasticity of Demand (η)	-1	-1	-1	-1
Discount Factor (β)	0.935	0.935	0.935	0.935
Fixed Cost of Acquisition FDI (C_A)	75.0	75.0	75.0	75.0
Fixed Cost of Greenfield FDI (C_G)	8.5	8.5	8.5	8.5

For simulations (1)–(4) I assume an initial market structure where domestic firms have a higher market share than the foreign firms. Firm $F2$ has less market share than firm $F1$ and firm $D2$ has a higher market share than firms $D1$ and $D3$. Firm $F2$ owns firm $D2$ in the initial equilibrium and sets prices such that they transfer some of their market share to firm $D2$ to avoid the trade costs.

4.1 Simulation 1: Baseline Simulation

I consider the first simulation the baseline case to which I can compare the other simulations. In this baseline case there is a future scheduled tariff that increases the trade cost factor by

[10]See simulation (5)–(7) in the Appendix to see how changes the market share of firm $F1$ and initial trade cost factor impact the calibrated fixed costs of FDI and overall strategy decision.

25%, a 10% higher wage rate in the domestic market, and a moderate productivity disruption to firm $D1$ if it is acquired by firm $F1$. Figure 1 shows the initial productivity disruption to firm $D1$ following acquisition and the dissipation path over the following periods.[11]

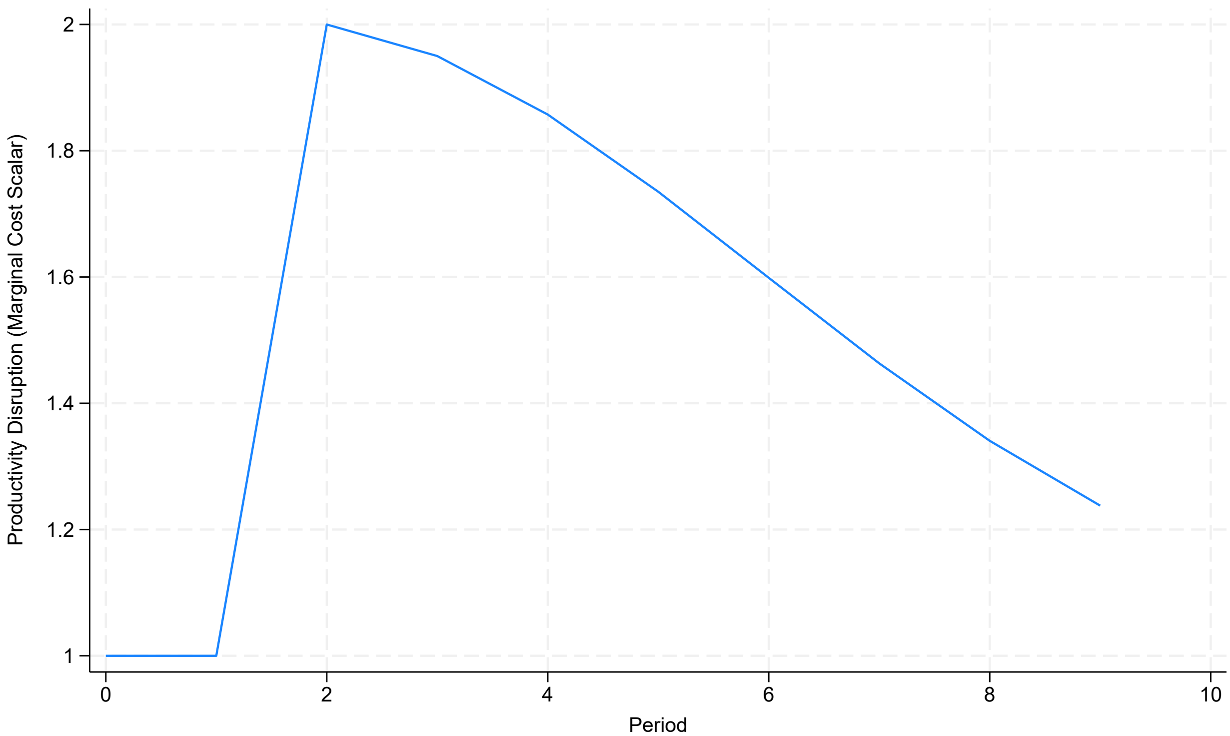

Figure 1: Productivity Disruption Path (Simulation 1)

Figure 2 is the decision matrix for firm $F1$ for the first simulation. The y-axis indicates the period when the tariff is implemented and the x-axis indicates when firm $F1$ expects tariff rate to return to the original rate. If there is a long time between the tariff announcement in period zero and the implementation of the tariff, firm $F1$ will consider strategies located higher up in the decision matrix. If firm $F1$ believes the duration of the tariff increase will be long, they are more likely to consider strategies located further to the right in the matrix. Each point in the matrix identifies the strategy that maximizes profits for firm $F1$ for the specific implementation period and expected duration of the tariff increase.

[11]The dissipation path is exogenous and can be adjusted to a path that makes sense for the specific industry that is being analyzed. I do not adjust the dissipation path for any of the simulations in this paper.

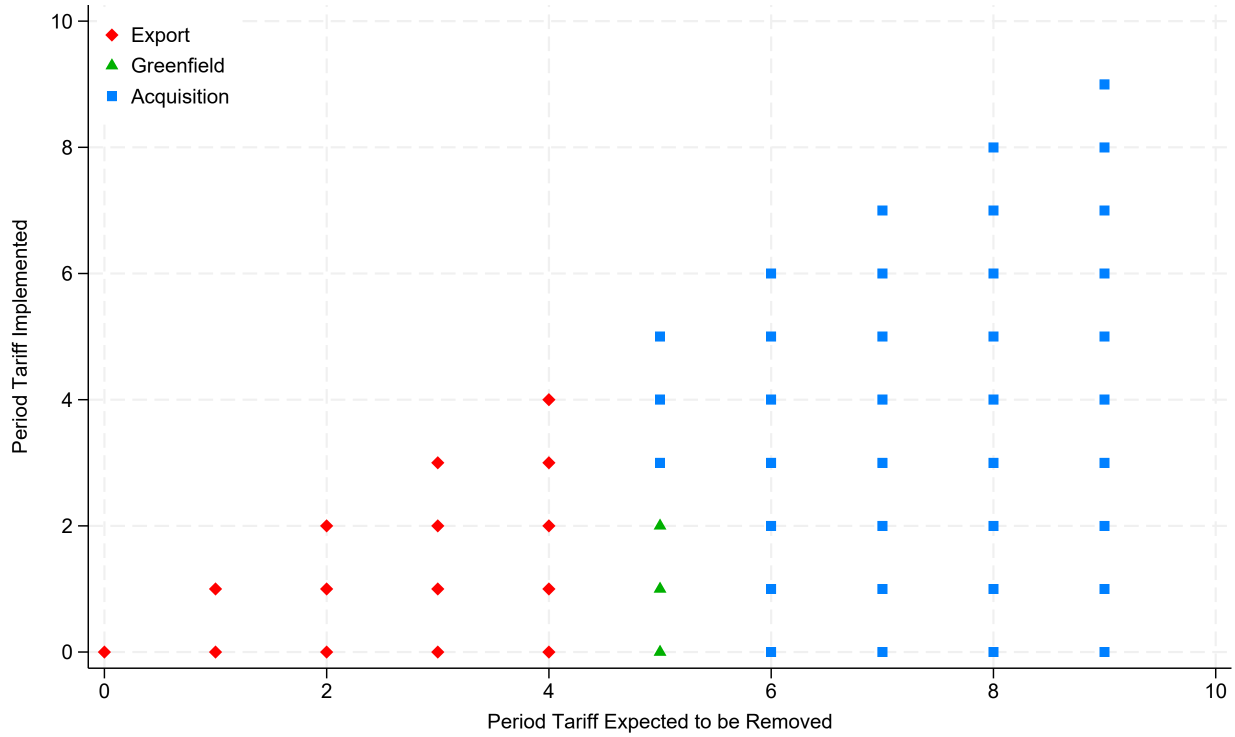

Figure 2: Simulation 1

In this simulation, firm $F1$ will choose to continue to export if they believe the announced tariff duration is only going to last a maximum of five periods. They will only choose the greenfield strategy in a small percentage of circumstances where the tariff is implemented in early periods and is only expected to be in place until period five. In all other scenarios, firm $F1$ will choose to acquire firm $D1$. In the long term scenarios, the productivity disruption dissipates, and the joint market share and profits of two firms is strictly better than continuing to export or greenfield FDI. Since this is a Bertrand differentiated products model, when firm $F1$ acquires firm $D1$ they still continue to export some products to the domestic market since they are slightly different than those products produced by firm $D1$. When firm $F1$ engages in greenfield FDI they set up transplant production and there is no reason to export to the domestic market since they can produce identical products from the domestic market. Absent any fixed costs or productivity disruption firms would always choose acquisition FDI if it were available to them since they would receive profits from two different firms and products.

4.2 Simulation 2: Large Tariff Increase

In the second simulation, I double the magnitude of the tariff increase from 25% to 50%. The larger tariff shifts the decision matrix such that firm $F1$ is more likely to choose greenfield FDI if the tariff is implemented in early periods, and the expected duration is in the medium to long-run. The large tariff increase in early periods decreases firm $F1$'s profits, making it difficult for firm $F1$ to afford the large fixed cost of FDI required in period one, and the productivity disruption to firm $D1$ in the periods directly following the acquisition. Only when the anticipated implementation period and duration of the tariff is in the long-run does the productivity disruption dissipate enough for the acquisition of firm $D1$ to be a viable strategy.

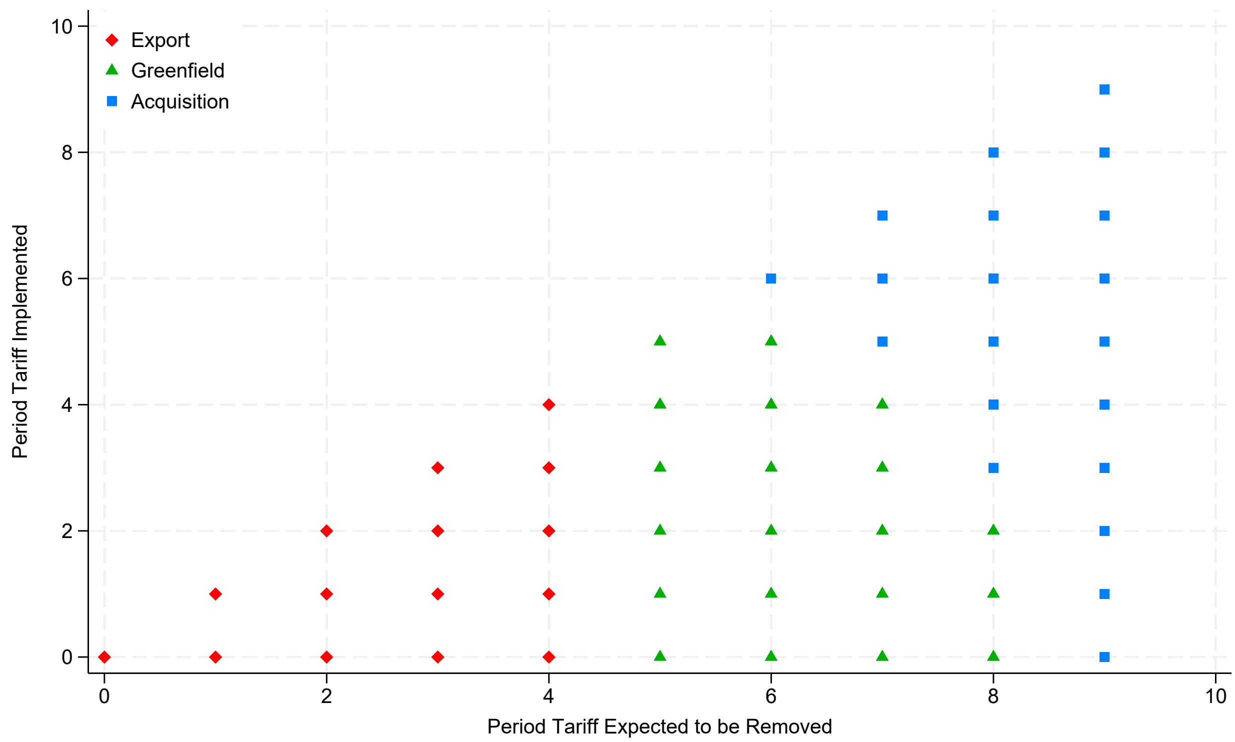

Figure 3: Simulation 2

Similar to simulation one, exporting is still the preferred strategy for short duration tariff increases. This is a common theme throughout all simulations. A tariff increase with little warning and an expected short lifespan does not warrant paying the fixed costs of FDI to establish domestic production to avoid a short lived variable cost increase.

4.3 Simulation 3: Large Productivity Disruption

The third simulation represents an industry where products are highly differentiated between firms and there is significant heterogeneity in the production practices and technologies between countries and firms. Acquiring a firm, transferring technology, and harmonizing production results in a large productivity disruption to the acquired firm. Figure 4 shows how the large productivity disruption dissipates over time.

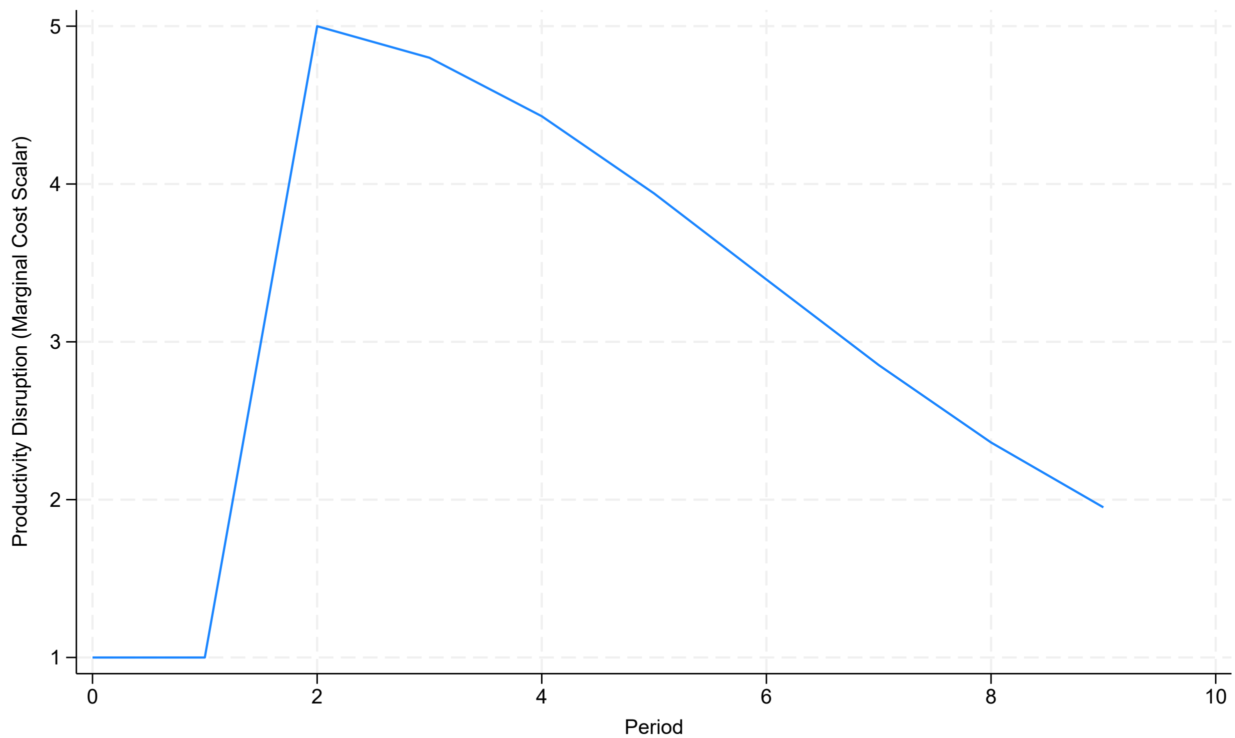

Figure 4: Productivity Disruption Path (Simulation 3)

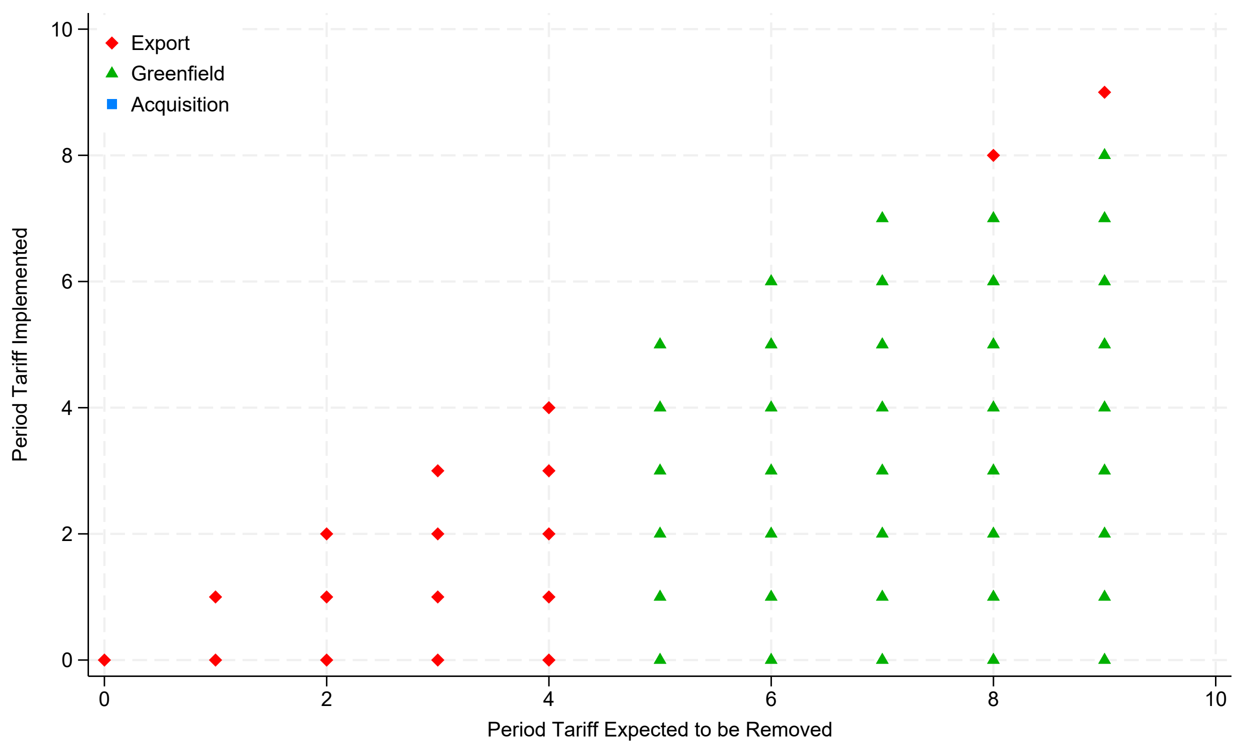

Figure 5: Simulation 3

The large productivity disruption eliminates acquisition as a viable strategy in any combination of implementation period and duration of tariff increases for the ten period model. The large disruption to $D1$'s productivity eliminates the advantage of receiving profits from both exports and the domestically owned firm. Greenfield becomes the dominant strategy to avoid the variable cost increase if the tariff is expected be in place longer than period four, except for two instances. In the two instances when the tariff is implemented in period eight and nine and expected to only be in place during those periods, continuing to export is the dominant strategy. This is driven by the relative wage rate. Firm $F1$ is willing to pay the slightly increased variable cost due to the wage rate as long as the cost savings from avoiding the tariff in the long-run makes up for it. At a point in the long-run, firm $F1$ reaches an inflection point where they are no longer willing to pay the wage difference for a large number of periods just to avoid a one-period tariff increase in the distant future. If the tariff is expected to last until period five, six, or seven, greenfield is the dominant strategy regardless of the period the tariff is implemented. In these scenarios, firm $F1$ does not hit the inflection point where the variable costs incurred from paying higher wages are greater than variable costs incurred from the future tariff increase. If I remove the difference in wages, greenfield FDI becomes the strictly dominant strategy in the medium to long-run.[12]

4.4 Simulation 4: No Productivity Disruption

In this simulation I look at an industry where there is little differentiation between products produced by different firms, and technology and production processes are homogeneous across countries and firms.

When there is no productivity disruption to the acquired firm, acquisition becomes the dominant strategy if the expected duration of the tariff increase is four periods or more. As long as the tariff increase is implemented long enough for the acquisition to take place and

[12]See simulation (3a) in the Appendix.

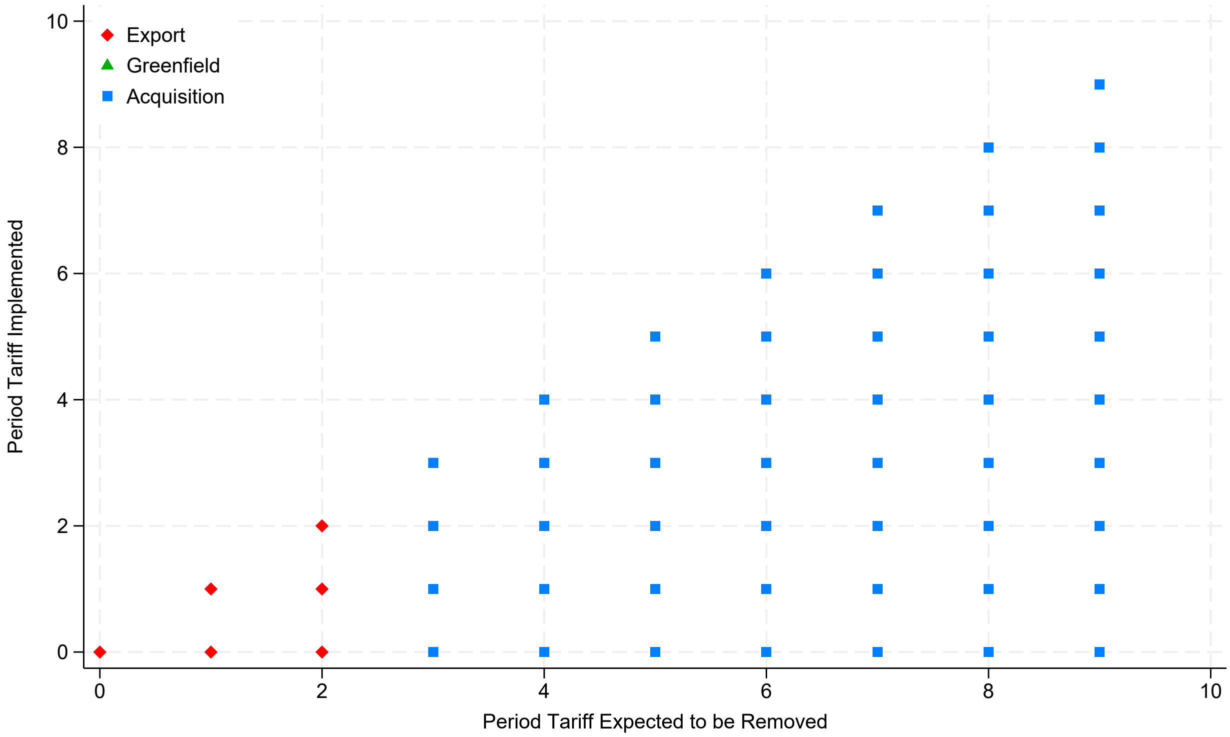

Figure 6: Simulation 4

firm $F1$ starts receiving profits from firm $D1$, they will always choose acquisition FDI. The seamless transition of ownership allows firm $F1$ quick and profitable access to the domestic market relative to the greenfield strategy.

5 Conclusion

Through a series of illustrative simulations, I show that in the medium to long-run, in industries where the expected productivity disruption to acquired firms is high, greenfield FDI becomes the more likely strategy. In industries where the productivity disruption to acquired firms is expected to be small, acquisition becomes the dominant FDI strategy. Short-run tariff increases are likely to result in no FDI to avoid the variable cost increase. Tekin-Koru (2009) produced similar findings when looking at the harmonization of the acquiring and acquired firms, but the dynamics of the model in my paper show that static models miss the heterogeneity of firm-level decision making in the face of anticipated tariff increases of varying expected duration.

I present the model with five firms, though it can be extended to any number of firms as long as the following necessary condition for the FDI fixed cost calibration is satisfied: at least one firm must be engaged in each type of supply strategy to the domestic market. The main finding and contribution of this paper—that the firm-level FDI decision is dependent on the anticipated timing of trade policy changes—will generalize to models with an arbitrary number of firms. Although, researchers analyzing scenarios with more firms—specifically more decision making firms—will have to consider more strategic interactions between firms. For example, if an additional exporting firm were added to the model, only one of the two exporting firms would be able to acquire the single available domestic firm.

I address the issue of quantifying the fixed cost of FDI by using the method developed in Riker and Schreiber (2019) to calibrate a probability distribution of fixed costs. The market structure requirements of this approach may limit my model's ability to analyze industries where no FDI currently exists. Future research can look for other ways to quantify the FDI fixed costs for such industries.

The decision by firms to engage in horizontal FDI to avoid tariff increases depends on the anticipated implementation date and expected duration of the tariff, fixed costs of FDI market shares, relative wage rates, and the extent of productivity disruption to acquired firms. The dynamic industry specific model in this paper provides a practical tool, with reasonable firm-level data requirements, that lays the groundwork for future research into the dynamics of firm-level FDI decision making.

That research could include the addition of uncertainty to the expected timing of tariff increases and expected fixed costs, the relaxing of the discrete choice constraint allowing firms to reassess and change their decisions in each period, allowing firms to acquire shares of firms rather than purchasing 100% ownership, and the addition of more firms. I assume that the firms have unlimited access to capital to fund their acquisition and greenfield investment, which could restrict both types of FDI.

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6 Appendix

Simulations (5)–(7) in the Appendix highlight how changing the initial expenditure shares, initial trade cost factor, and/or the relative wage ratio impact the calibrated fixed costs of FDI. The calibrated fixed cost values in bold in Table 2 are fixed costs that change relative to the baseline simulation (1) from Section 4. An increase in the market share of firm $F1$ decreases the calibrated fixed cost of acquisition FDI and increases the calibrated fixed cost of greenfield FDI. A higher initial trade cost factor also increases the calibrated fixed cost of acquisition FDI while increasing the calibrated fixed cost of greenfield FDI. A decrease in the initial market share of firm $F1$ results in an increase in the calibrated fixed cost of acquisition FDI and a decrease in the calibrated fixed cost of greenfield FDI.

Simulation (3a) illustrates how a decrease in the relative wage ratio eliminates the inflection point for the ten period model described in simulation (3) from Section 4 and greenfield FDI becomes the strictly dominant strategy. The decrease in relative wage ratio to one also slightly decreases the fixed cost of greenfield FDI and the fixed cost of acquisition FDI remains the same. The decision matrix for this simulation is shown in Figure 10.

Table 2: Inputs for Additional Illustrative Simulations

	(5)	(6)	(7)	(3a)
Expenditure on $D1$ (V_{D1})	200	200	200	200
Expenditure on $D2$ (V_{D2})	250	250	250	250
Expenditure on $D3$ (V_{D3})	200	200	200	200
Expenditure on $F1$ (V_{F1})	150	**250**	**30**	150
Expenditure on $F2$ (V_{F2})	100	100	100	100
Initial Productivity Disruption (γ)	2	2	2	**5**
Wage Ratio (ω)	1.1	1.1	1.1	**1.0**
Initial Trade Cost (τ_0)	**1.15**	1.05	1.05	1.05
New Trade Cost (τ_1)	1.3	1.3	1.3	1.55
Elasticity of Substitution (σ)	4	4	4	4
Total Industry Price Elasticity of Demand (η)	-1	-1	-1	-1
Discount Factor (β)	0.935	0.935	0.935	0.935
Fixed Cost of Acquisition FDI (C_A)	**74.6**	**73.0**	**79.0**	75.0
Fixed Cost of Greenfield FDI (C_G)	**22.7**	**10.7**	**6.0**	**8.3**

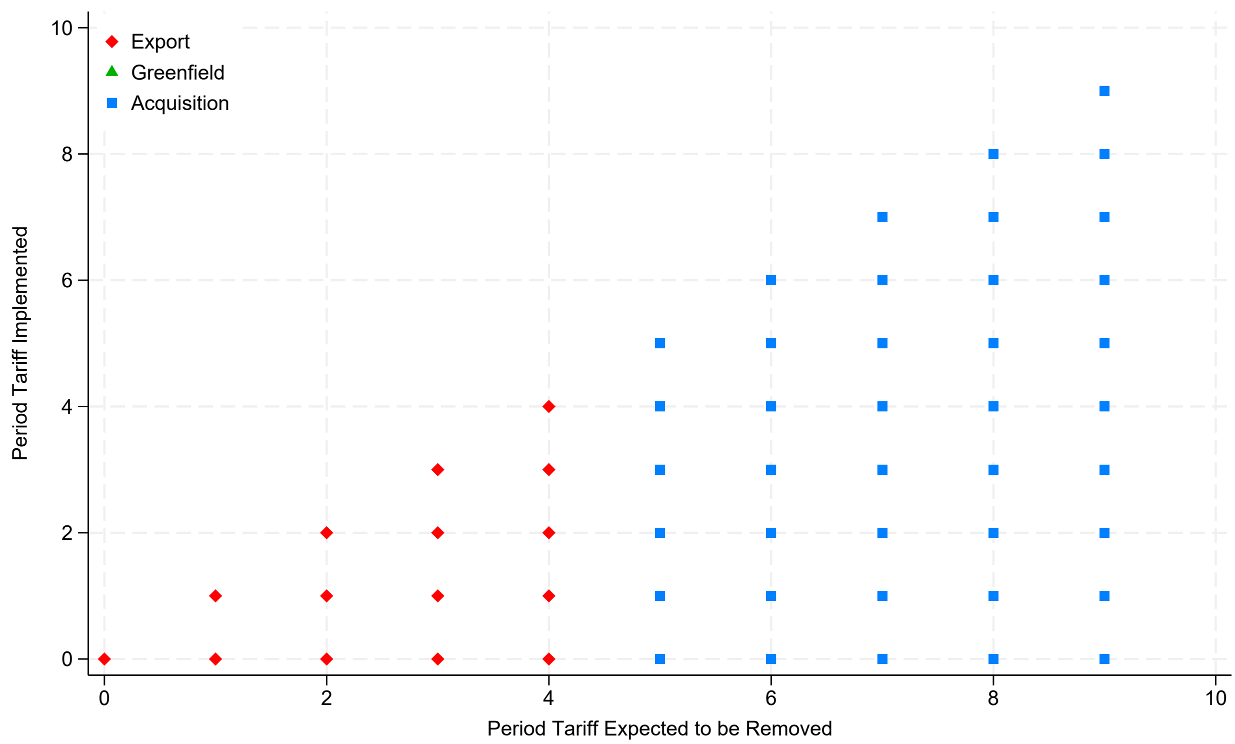

Figure 7: Simulation 5

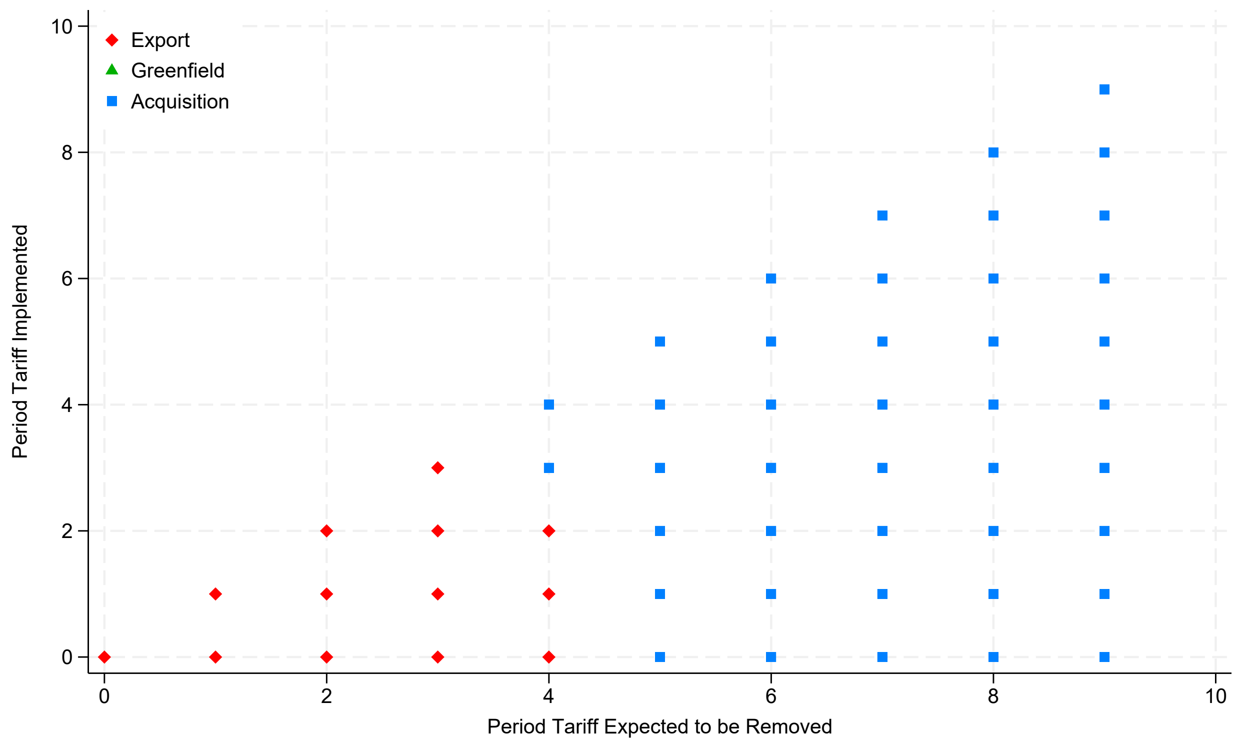

Figure 8: Simulation 6

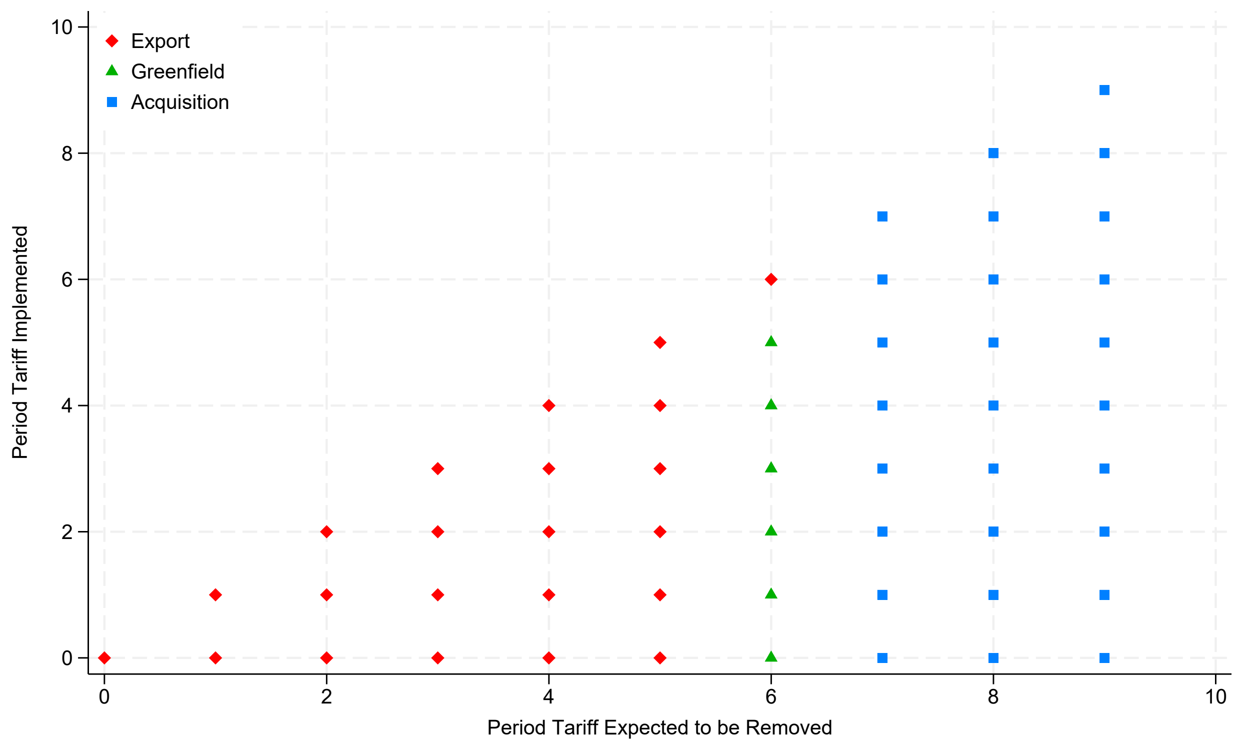

Figure 9: Simulation 7

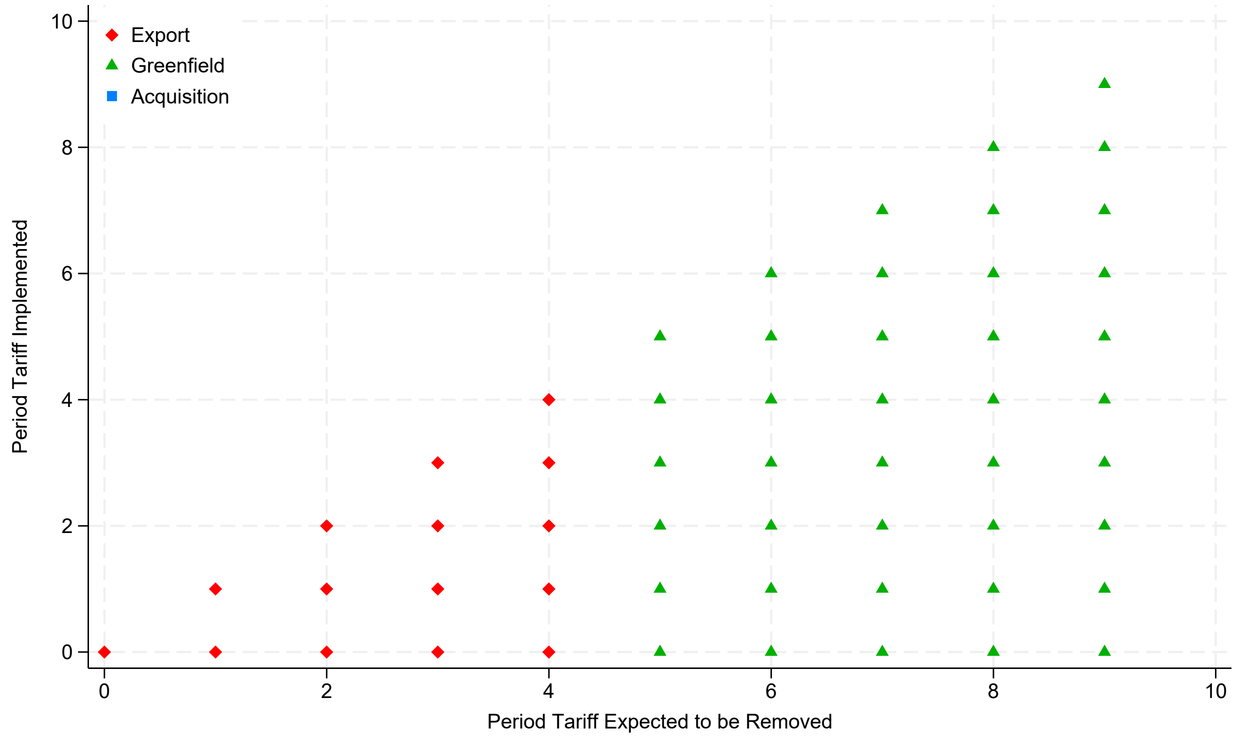

Figure 10: Simulation 3a