Holdup and Comparative Advantage*

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Abstract

We consider a setting where firms need to make irreversible investments to exploit a country's comparative advantage. Firms are then susceptible to ex-post rent extraction by a transit country or by other agents that are able to limit access to world markets. We develop a general equilibrium model where this potential holdup problem makes such countries poorer and less likely to invest in technology that generates their comparative advantage. The predictions of the model are examined using gravity equations and a new measure of distances that explicitly considers the location of the closest ports. The evidence is consistent with less trade by landlocked countries as a result of the holdup problem we examine.

Keywords: holdup, trade agreements, technology, foreign investments, gravity model

JEL: F10, F50, O24, O40.

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“The commerce besides which any nation can carry on by means of a river which does not break itself into any great number of branches or canals, and which runs into another territory before it reaches the sea, can never be very considerable; because it is always in the power of the nations who possess that other territory to obstruct the communication between the upper country and the sea. The navigation of the Danube is of very little use to the different states of Bavaria, Austria and Hungary, in comparison of what it would be if any of them possessed the whole of its course till it falls into the Black Sea.”

Adam Smith (1776), [1979, p125-126].

1 Introduction

Countries can achieve large efficiency gains by specializing according to comparative advantage. However, fears that opening an economy to trade and foreign investors will put foreign powers in a position to extract rents are central to many policy debates. We know that factors that affect the splitting of the surplus generated by trade between two firms can have important consequences for how to organize production (see for instance Coase (1937) or Grossman and Hart (1986) - Lafontaine and Slade (2007) survey the empirical evidence). Thus, it seems hard to dismiss the arguments about distribution of gains from trade between countries out of hand.

In the present paper we write down a general equilibrium model that allow us to examine the effects of trade liberalization in a setting where asymmetric bargaining positions affect the distribution of the gains from trade. A key feature of our model is that an investment is needed in a first stage to develop a comparative advantage in a second stage. Countries whose most direct route to the world market passes through a transit country (or another type of hub) are vulnerable rent extraction by the party who controls the trade route. This has an impact on both trade volume and incentives to develop a comparative advantage. The

perhaps starkest example where such setting is relevant is trade by landlocked countries. Less starkly we could think of cases where a country is dependent on an intermediary to reach world markets: This could be a monopsonistic buyer of the main product that a country would export if it specialized according to comparative advantage (think of a 1920s central American country contemplating specializing in banana growing with United Fruit as the main buyer) or a shipping cartel that controls trade routes to a small country (see Hummels, Lugovskyy and Skiba (2009) for an analysis of market power in international shipping).

From existing literature we know that landlocked countries trade less and face higher transport costs than coastal nations: A dummy for landlocked is associated with a negative effect on bilateral trade in gravity equations, see for instance Frankel and Romer (1999) or Rose (2004). For evidence of higher trade costs faced by landlocked countries see Limão and Venables (2001) or Raballand, Kunth and Auty (2005). Recent micro evidence on the trade costs facing landlocked countries however points to that longer overland distances per se are not the main reason for higher trade costs. For instance a report by the World Bank establishes that (Arvis, Raballand and Marteau (2007), p. 1)

"The main sources of costs [for landlocked economies] are not only physical constraints but widespread rent activities and severe flaws in the implementation of the transit systems". As an example of waste due to a holdup problem between countries Collier and Venables (2008) point to Guinea's insistence that iron ore from a new Rio Tinto mine be exported via a new domestic railway line, rather than via an existing railway line that ends in neighboring Liberia.

This suggests that the holdup problem that Adam Smith pointed to in the "Wealth of Nations" is relevant also today and we use our model to characterize how investments, welfare and trade regime depend on the costs of investing in technology and on the possibility for a country to block access to world markets. We first introduce a model with the country of interest and a rest of the world only. We then consider the case where the trade of the country of interest has to pass through a transit country to reach world markets. To point out

the wider applications, and stress the relation to the partial equilibrium holdup literature, the landlocked country is referred to as Upstream and the transit country as Downstream. We show that free trade increases income and the range of profitable investments in Upstream. We also show conditions under which opening up for trade will induce investments in Upstream, and that such an opening can be optimal even absent a commitment from Downstream. We show that if the investment in technology leads to a large enough improvement (equivalently, then investment cost is low enough), then it is optimal for Downstream to charge fees that are intermediate and still allow Upstream to obtain positive gains from trade. However, the volume traded, welfare in Upstream and the cost at which investment in technology is worth undertaking are still lower. For smaller improvements in technology, the holdup problem can be the reason why Upstream does not develop a comparative advantage. Under some parameter values, there is also a potential commitment problem where Downstream would like to induce investment and trade, but has an incentive to ex-post renegotiate these fees. In such case, Upstream may be better off to commit to stay in autarky.

We extend the model to address the effect of foreign ownership of firms in Upstream. In our model foreign ownership serves to alleviate the holdup problem. If policy makers in Downstream take into account the business interests of their residents, they make the trade conditions more favorable for Upstream. This leads to an increase of technology investments and wages in Upstream that arises purely from the more favorable trade conditions, and can be beneficial for both countries.

We proceed to examine the implications in a gravity model of bilateral imports using data for 1950-2000. To avoid systematically assigning too low bilateral distances to landlocked countries we replace the great circle distance ("as the crow flies") typically used in the gravity literature with distances from main city to main city via the closest ports. Our results point to that trading via a transit country reduces imports by more than 50 percent. We examine the role of free trade agreements with transit countries as well as foreign direct investment to counterweigh the holdup problem. For free trade agreements there is a borderline significant

positive effect while, consistent with the predictions of the model, there is evidence that foreign ownership is associated with a weakening of the holdup effect.

As indicated by the quote from the Wealth of Nations we are not the first to recognize the potential for holdup facing landlocked countries - but to the best of our knowledge it has not been modeled previously.¹ The closest precursor is McLaren (1997) who examines a two-country Ricardian model with the only non-standard feature that firms in a first period choose which industry to be present in and then in period 2 trade. He shows that a small country may have higher welfare in autarky than if it specializes according to comparative advantage - since specialization makes the small country vulnerable to rent extraction from the large country.² The result is thus the opposite from a standard trade model, without the sectorial lock in of investments, where a small country will gain from unilateral trade liberalization (see for instance Bagwell and Staiger (1999)). Compared to McLaren (1997) we consider imperfect competition, rather than price taking behavior by all firms, and focus on a different trade friction - the bargaining power of a transit country. Also, modelling the investment decision, rather than having firms choosing their industry as in McLaren (1997), allows us to examine the interplay between investments and trade policy without forcing countries to maintain a sub-optimal industry specialization. Furthermore, there are additional novel predictions in our paper regarding the effect of foreign ownership of firms on the value of firms, investments and welfare through the effect of ownership of firms on optimal trade policy.

A setting with relation specific investment has been applied to international trade in for instance Antràs and Helpman (2004) and Grossman and Helpman (2005), see Helpman (2006) for a survey. Recent related work by Ornelas and Turner (2011), Antràs and Staiger

¹A non-model based precursor is Hirschman (1945) who examines how the Nazi regime in Germany used trade policy to wield power. During the 1960s a set of ideas known as "dependency theory" became popular as a framework to analyze in particular Latin American development. It built partly on the Prébisch-Singer notion that deteriorating terms of trade for primary products make developing countries loose out on trade (see for instance Prébisch 1959) and partly on Marxist analysis (see for instance Gunder Frank (1967)). As will become apparent, our framework is very different.

²McLaren (2002) examines regionalism vs free trade in a similar setting with 3 equally sized countries - investment decisions are made in period 1 and trade negotiations follow in period 2.

(2012) and Conconi et. al. (2012) use two-country models to examine links between trade policy and the organization of firms in a setting with relation-specific investments. Ornelas and Turner for instance show that an import tariff may raise welfare by making foreign inputs costlier and thus provide domestic suppliers of specialized inputs a stronger bargaining position - which serves to alleviate a hold-up problem. These works do not explore the potential for holdup at the country level that is our focus. By modelling the optimal technology investments the paper also relates to the endogenous growth literature (e.g. Romer (1990), Aghion and Howitt (1992)). In particular, it relates to the literature that addresses the relationship between trade and the evolution of technology (e.g. Grossman and Helpman (1991), Acemoglu (2002)). Unlike the current paper, this literature mainly focuses on the effects of technology spillovers across countries, and does not address the interaction between technology and optimal trade arrangements. Lastly we should also point to the papers that analyze the equilibrium fees set by successive jurisdictions that traders need to pass - in these papers the silk road linking ancient China and Rome is taken as the motivating example. Karni and Chakrabarty (1997) show how the double marginalization problem associated with each jurisdiction adding its fee raises price. Feinberg and Kamien (2001) establish that with sequential trade the double marginalization problem may instead be replaced by a holdup problem - anticipating the high fees the merchant may never set out from his home.³ Apart from that we model the general equilibrium and resulting wages, investments and trade patterns, a key difference with respect to these latter papers is that we assume that the final destination for exports is a price taking "rest-of-the-world", rather than a sophisticated rent extractor.

Section 2 sets up the model and Section 3 outlines main predictions from our model and examines trade patterns in a gravity framework. We conclude in Section 4.

³Miyagiwa (2009) shows how a trigger strategy can sustain trade in a repeated game version of the Feinberg and Kamien (2001) setting.

Figure 1: Producers and production interactions in country c .

2 The model

We focus on a one period general equilibrium model of bilateral trade between a small country c and the rest of the world, indexed with w , in the presence of a potential holdup problem. Figure 1 illustrates the interactions in the production side of country c . We introduce several layers of production, as it allows to show in a transparent setting how investment in technology can ultimately lead to specialization and potential gains from trade, while keeping the model in the spirit of familiar settings. There is a final composite good that is assumed to be non-tradable. The final good uses two specialized goods as inputs that are tradable - goods A and F .

We assume that if country c does not invest in technology, then it is identical to the rest of the world and naturally there are no incentives to trade. However, country c is assumed to have access to a technology, which allows it to develop a comparative advantage in producing one of the tradable goods - specialized good A . Modelling of technology investments is the spirit of Aghion and Howitt (1992), and we assume that a fixed investment in technology in c leads to an improvement of the quality of capital goods used in sector A .

In terms of modelling the trade incentives, our model is Ricardian. If country c invests in technology, then the productivity of specialized good sector A increases relative to specialized goods sector F . As the result, the A sector will be relatively better able to increase wages and thus attract labor. This generates incentives of country c to trade with the rest of the world by exporting good A and importing good F . Modelling the final good as a composite good produced from the two specialized goods is the easiest way to capture consumers' preferences over these two goods.

After describing this benchmark model in Section 2.1, Section 2.2 addresses our main question - the holdup problem. Namely, we argue that the trade between country c and the rest of the world depends on the geographical location of the country c in question. The country in question could have a direct access to the world market, or it would need to trade through a transit country. In the latter case we refer to the country in question as Upstream and the transit country as Downstream. Due to its' location, Downstream has an opportunity to charge fees for all the imports and exports that will pass through the country. We assume that the objective of the government in Downstream is to maximize its own consumers' welfare and will distribute all the returns from fees to consumers in Downstream. We will show how these fees reduce the trade volume between Upstream and the rest of the world if the latter still chooses to invest. Fees also make it less likely that Upstream will develop a comparative advantage to start with. Section 2.3 shows how the holdup problem is partially alleviated if firms in Upstream are owned by agents in Downstream. The model allows us to derive empirically testable implications and we will focus on the expression for import volume.

In terms of timing, we assume that investment in technology is made up-front (at the beginning of the period) and all other production and (potentially) trade occurs at the end of the period. In the case that the country in question is Upstream, we assume that fees are decided in the middle of the period, i.e., after the investment decision has been made and before the rest of production and trade occurs.

Finally, in the model we abstract from the physical trading cost to keep the model simpler and because these costs are well understood in the literature. However, we take these costs into account in our empirical specification.

2.1 Benchmark model

2.1.1 Setup

Production of specialized goods: All countries can produce two specialized goods: an F -good whose quality is fixed in all countries and an A -good whose quality is fixed in the rest of the world, but can be improved in the small country c . We denote these goods and corresponding sectors with $J \in \{A, F\}$. We use similar notation to denote the quality of specialized goods in country $i \in \{c, w\}$ as J^i . As the quality of the F -good is fixed, it holds that $F^i = F$ for all i . The quality of the A -good in the rest of the world is fixed as well and without a loss of generality, we normalize it to $A^w = 1$. At the beginning of the period, firms in country c have an opportunity to invest in improving the quality of A -good for a fixed investment I . All other production takes place at the end of the period and for country c the quality of A -good is

$$A^c = \begin{cases} \bar{A} & \text{if firms in country } c \text{ chose to invest in technology} \\ 1 & \text{if firms in country } c \text{ chose not to invest in technology.} \end{cases} \quad (1)$$

We specify the technology investment decision at the end of this section.

A specialized good $J \in \{A, F\}$ in country $i \in \{c, w\}$ is produced by a competitive specialized goods sector who produces χ_J^i units of the specialized with Cobb-Douglas production technology

$$\chi_J^i = (l_J^i L^i J^i)^{1-\alpha} x_J^{i\alpha}, \quad (2)$$

where l_J^i is the share of labor force employed in by the producers of J -good, L^i is the total labor force, $J^i \in \{F, A^i\}$ is the quality of technology, x_J^i is the capital used in J sector and

$\alpha = (0, 1)$ is a constant. Capital and labor are not mobile across countries and labor market clearing implies that $l_A^i + l_F^i = 1$. We normalize the labor force in country c to $L^c = 1$ and assume that the labor force in the rest of the world, L^w , is noticeably larger. This will guarantee that the rest of the world is always incompletely specialized in equilibrium.⁴

Specialized goods producers in country $i \in \{c, w\}$ sector $J \in \{A, F\}$ take the price of specialized good p_J^i , wage w_J^i and price of capital $p_{x,J}^i$ as given and

$$\max_{l_{j,t}^i, x_{j,t}^i} p_J^i \chi_J^i - w_J^i l_J^i L^i - p_{x,J}^i x_J^i \text{ st. (2)}. \quad (3)$$

Technology firms: In the spirit of growth literature (e.g., Aghion and Howitt (1992)), we assume that sector specific capital goods are produced by a monopolistic technology firms in each country. Without a loss on generality, we assume that both capital goods are produced by the same monopoly, who takes into account the demand curve for capital goods x_A^i and x_J^i by the specialized good's sector and maximizes gross profits

$$\max_{x_A^i, x_F^i} \pi^i = \sum_{j=A,F} p_{x,j}^i x_j^i - x_j^i \text{ st. demand curves derived from (3)}. \quad (4)$$

As discussed above, the technology producer in country c can improve the quality of capital goods in sector A by investing I . It is clear that investment in technology pays off if

$$\pi^c(\bar{A}, F) - \pi^c(1, F) \geq I. \quad (5)$$

Final good production: We take the final good as a numeraire and assume that a competitive final good's sector combines two specialized good in a final (consumption) good with

⁴See Section 2.1.3 and Appendix B.4 for more details and the precise condition for L^w .

the following Cobb-Douglas technology,⁵

$$Y^i = (Y_A^i)^\gamma (Y_F^i)^{1-\gamma}, \quad (6)$$

where Y_F^i and Y_A^i denote the quantity of specialized goods A and F used in country $i \in \{c, w\}$ and $\gamma \in (0, 1)$ is a constant. Final goods sector solves

$$\max_{Y_A^i, Y_F^i} Y^i - p_A^i Y_A^i - p_F^i Y_F^i \text{ st. (6)}, \quad (7)$$

where p_F^i and p_A^i are the prices of good A and F in country $i \in \{c, w\}$.

Consumption: Consumers are endowed with labor and own firms in their country. In our benchmark model we assume that all firms are owned by local consumers and therefore average per-capita consumption⁶ is

$$\frac{C^i}{L^i} = w_A^i l_A^i + w_F^i l_F^i + \frac{\pi^i - I^i \tilde{1}^i}{L^i}, \quad (8)$$

where $w_A^i l_A^i + w_F^i l_F^i$ is the wage income; $\pi^i - I^i \tilde{1}^i$ is net profits from owning the technology firms, $\tilde{1}^i$ is an indicator function such that $\tilde{1}^i = 1$ if country i invests in technology and $\tilde{1}^i = 0$ otherwise. Note that $\tilde{1}^w = 0$ as the rest of the world lacks the technology investment opportunity. As a measure of utility, we consider any monotonically increasing function of average per capita consumption. Consumers optimally use all their income to consume. While they take the income from owning the firms as given, they choose where to supply their labor.

⁵Similar results would be obtained for any final good production function as long as A-good and F-good are not perfect substitutes, results with a more general CES production function are available upon request.

⁶An alternative way to specify aggregate consumption is to note that the aggregate goods market condition is $C^i = Y^i - I^i \tilde{1}^i - x_A^i - x_F^i$ as the final good is used for consumption, and investments in technology and capital.

2.1.2 Optimal production decisions

Before considering autarky of free trade it is useful too derive some intermediate outcomes regarding production decisions.

Lemma 1 *Given the price of specialized good p_J^i and the share of labor l_J^i supplied to sector $J \in \{A, F\}$ in country $i \in \{c, w\}$, the optimal quantity of good J produced, profits and wages are respectively*

$$\chi_J^i = \alpha^{\frac{2\alpha}{1-\alpha}} L^i (p_J^i)^{\frac{\alpha}{1-\alpha}} l_J^i J^i, \quad (9)$$

$$\pi^i = (1 - \alpha) \alpha \cdot \alpha^{\frac{2\alpha}{1-\alpha}} L^i \left((p_A^i)^{\frac{1}{1-\alpha}} l_A^i A^i + (p_F^i)^{\frac{1}{1-\alpha}} l_F^i F \right), \quad (10)$$

$$w^i = \max [w_A^i, w_F^i], \text{ where } w_J^i \equiv \alpha^{\frac{2\alpha}{1-\alpha}} (1 - \alpha) (p_J^i)^{\frac{1}{1-\alpha}} J^i \quad (11)$$

Proof. See Appendix B.1. ■

The intuition of Lemma 1 is straightforward, in any country the production of a specialized good $J \in \{A, F\}$ is higher if the price of that good is higher and the good is of higher quality (i.e., J^i is higher).

It also follows immediately from the first order condition of the final good sector problem (7) that

$$\frac{p_A^i}{p_F^i} = \frac{\gamma}{1 - \gamma} \frac{Y_F^i}{Y_A^i} \quad (12)$$

$$(p_A^i)^\gamma (p_F^i)^{1-\gamma} = \theta \equiv \gamma^\gamma (1 - \gamma)^{1-\gamma} \quad (13)$$

2.1.3 Autarky and free trade in the benchmark model

Autarky: Final good's market clearing conditions for the autarky are

$$Y_A^i = \chi_A^i \text{ and } Y_F^i = \chi_F^i \text{ for } i \in \{c, w\} \quad (14)$$

Lemma 2 *In autarky, the specialized goods prices in the rest of the world are*

$$p_A^w = \theta F^{(1-\gamma)(1-\alpha)} \text{ and } p_F^w = \theta F^{-\gamma(1-\alpha)} \quad (15)$$

and in the country c are

$$\begin{cases} p_A^c = \theta F^{(1-\gamma)(1-\alpha)} \text{ and } p_F^c = \theta F^{-\gamma(1-\alpha)} & \text{if } \tilde{1}^c = 0 \\ p_A^c = \theta \left(\frac{F}{A}\right)^{(1-\gamma)(1-\alpha)} \text{ and } p_F^c = \theta \left(\frac{F}{A}\right)^{-\gamma(1-\alpha)} & \text{if } \tilde{1}^c = 1. \end{cases} \quad (16)$$

The country c invests in technology if

$$I \leq I^{aut}, \text{ where } I^{aut} \equiv \alpha \Gamma (\bar{A}^\gamma - 1) \quad (17)$$

and consumption per capita in the rest of the world is

$$\frac{C^{w-aut}}{L^{w-aut}} = \bar{C} \equiv \Gamma (1 + \alpha) \quad (18)$$

and in the country c is

$$C^{c-aut} = \begin{cases} \bar{C} & \text{if } \tilde{1}^c = 0 \\ \bar{C} + \Gamma (\bar{A}^\gamma - 1) + (I^{aut} - I) & \text{if } \tilde{1}^c = 1, \end{cases} \quad (19)$$

where constant

$$\Gamma \equiv (1 - \alpha) \alpha^{\frac{2\alpha}{1-\alpha}} F^{(1-\gamma)} \theta^{\frac{1}{1-\alpha}}. \quad (20)$$

Proof. See Appendix B.2. ■

If investment in technology pays off, i.e. $I^{aut} \geq I$, then consumption in the country c is higher than in the rest of the world.⁷ It is immediate that if country c does not invest in

⁷As in most of the endogenous growth models (e.g. Romer (1990), Aghion and Howitt (1992), Grossman and Helpmann (1991)) the aggregate benefit of investment in technology is higher than the private benefits for the technology producing firms, i.e., even if $I^{aut} = I$, consumption in country c is higher in the than in the case of no investments. This is because investments in technology lead to higher wages that are not

technology, then there are no benefits of trade between country c and the rest of the world as two prices of specialized goods are the same. However, if country c does invest, then the autarky price in country c is lower for good A and higher for good F . Therefore, in the case of trade there are incentives for country c to export good A and import good F .

Free trade: In the case of free trade, the law of one price holds and $p_J^c = p_J^w$ for $J \in \{A, F\}$. Furthermore, the current account must be balanced,

$$p_A (Y_A^i - \chi_A^i) + p_F (\chi_F^i - Y_F^i) = 0, \quad (21)$$

for $i = \{c, w\}$. If there are two countries then the worldwide goods market clearing condition is $\chi_J^c + \chi_J^w = Y_J^c + Y_J^w$ for $J \in \{A, F\}$.

We assumed that the rest of the world is large enough, such that the world is always incompletely specialized.⁸ Therefore, it must hold that $w_A^w = w_F^w$, which from (11) and (13) implies that world prices are given by the autarky prices in the rest of the world (15), i.e.,

$$p_A = \theta F^{(1-\gamma)(1-\alpha)} \text{ and } p_F = \theta F^{-\gamma(1-\alpha)}. \quad (22)$$

Due to this all the outcomes in the rest of the world are the same in autarky and in free trade.

It also follows that if country c invests in technology, i.e., $\tilde{1}^c = 1$ and $A^c = \bar{A}$, then the wages in A -good sector are higher than in F -good sector and the country will be fully specialized in A -good. Namely, in such case from (11) $w_A^c > w_F^c \Leftrightarrow (p_A)^{\frac{1}{1-\alpha}} \bar{A} > (p_F)^{\frac{1}{1-\alpha}} F \Leftrightarrow F^{(1-\gamma)} \bar{A} > F^{(1-\gamma)} \Leftrightarrow \bar{A} > 1$, and from (8), it is clear that it is optimal for consumers to allocate all their labor endowment to the A -sector, i.e., $l_A^c = 1$.

reflected in the profits of technology producers.

⁸Appendix B.4 proves that if $N \geq 1$ countries are fully specialized in good A , then the world is incompletely specialized as long as $L^w \geq N \cdot \frac{1-\gamma}{\gamma} \bar{A}$. While not crucial, we assume that this condition always holds as it simplifies the model.

Lemma 3 *In the case of free trade, country c invests in technology, $\tilde{1}^c = 1$ if*

$$I \leq I^{free_trade}, \text{ where } I^{free_trade} \equiv \alpha\Gamma(\bar{A} - 1) \quad (23)$$

and consumption in the country c is

$$C^{c_free_trade} = \begin{cases} \bar{C} & \text{if } \tilde{1}^c = 0 \\ \bar{C} + \Gamma(\bar{A} - 1) + (I^{free_trade} - I) & \text{if } \tilde{1}^c = 1. \end{cases} \quad (24)$$

If country c invests in technology, then import by country c is

$$Y_F^c - \chi_F^c = (1 - \gamma) F^{(1-\gamma)\alpha} \alpha^{\frac{2\alpha}{1-\alpha}} \theta^{\frac{\alpha}{1-\alpha}} \bar{A}. \quad (25)$$

Proof. See Appendix B.3. ■

Comparing Lemma 3 and Lemma 4 we can see that openness to trade makes it more likely that the country c invests in technology, as $I^{free_trade} > I^{aut} \Leftrightarrow \alpha\Gamma(\bar{A} - 1) > \alpha\Gamma(\bar{A}^\gamma - 1) \Leftrightarrow \bar{A}^{1-\gamma} > 1$. Also consumption in country c is likely to be higher, both because investment in technology is more likely to be profitable (as $I^{free_trade} - I > I^{aut} - I$) and there are bigger benefits from better technology in terms of higher wages (as $\Gamma(\bar{A} - 1) > \Gamma(\bar{A}^\gamma - 1)$).

As we will now focus on the potential holdup problem, it is worth noting that free trade between a country and the rest of the worlds is likely to occur if either the country has a direct route to transport its goods to the rest of the world, or it has a free trade agreement with any countries that are on its route the world market.

2.2 Holdup problem

We maintain the setting as in Section 2.1 with the following modification. Assume that the country in question, potentially trading with the rest of the world, does not have a direct access to the world market and all its trade must pass through a third country. We call the

country in question Upstream, $c = u$ and the third country as Downstream. In addition to any production that occurs in Downstream (and its' trade with the rest of the world), Downstream has a opportunity to charge fees for imports and exports between Upstream and the rest of the world. Given our results in the previous Section, it is clear that trade between Upstream and the rest of the world can only be profitable if Upstream develops a comparative advantage in the A -good, in which case it would export good A and import good F . We assume that due to the holdup problem, Downstream taxes the goods traded such that provided the world prices of p_A and p_F , the prices that Upstream faces are $p_A^u = p_A (1 - \tau_A)$ and $p_F^u = p_F (1 + \tau_F)$ respectively, where $\tau_A, \tau_F \geq 0$.⁹ If Upstream is still willing to trade under these conditions, then Downstream earns variable fee income of

$$T_v^d = p_A \tau_A (\chi_A^u - Y_A^u) + p_F \tau_F (Y_A^u - \chi_A^u). \quad (26)$$

As we maintain the assumption that the rest of the world is large enough to remain incompletely specialized, the world prices are given by the autarky prices in the rest of the world given by (22).

We assume that the government in Downstream aims to maximize local consumer's welfare. We should note that it is not crucial to specify production in Downstream, as the fees regarding the trade between Upstream and the rest of the world do not affect production decisions in Downstream in many relevant settings.¹⁰ Abstracting from trading incentives between Upstream and Downstream is natural in this setting as any trade between these

⁹ Another possibility is a fixed fee, which is perhaps harder to implement for Downstream but can also lead to additional rent extraction. We have solved the model also for that specification and results are available upon request.

¹⁰ For example, we could assume that Downstream has the same structure as the small country analyzed in Section 2.1. The modification here would be that per capita consumption, Downstream, $c = d$ (8) would be given by $C^d = w_A^d l_A^d + w_F^d l_F^d + (\pi^d - I^d \bar{1}^d) + T^d$, where T^d is a lump-sum transfer of the fee income to its' consumers. It is easy to verify that with large enough labor in the rest of the world, all production decisions in Downstream are unaffected (and both countries are too small to have a price impact in the rest of the world). It can also be verified that in such settings it will never be the case that Upstream specializes in A -good and Downstream does not, hence the countries lack incentives to directly trade with each other. Maximizing welfare of consumer's in Downstream is then equivalent to maximizing the fee income. Alternatively, Downstream could have different preferences and specialize in trading different goods than A and F with the rest of the world.

two countries is not subject to a holdup problem.

The current account in Upstream is given by

$$p_A^u (\chi_A^u - Y_A^u) + p_F^u (Y_A^u - \chi_A^u) = 0. \quad (27)$$

2.2.1 Solution of the model with a holdup.

We should first note that the relationship between the fees charged on imports and exports by Upstream are interdependent. Having normalized the price of final good to 1, the price index (13) must hold in all countries and from world prices (22). Hence if Upstream trades, it must hold that

$$(p_A^u)^\gamma (p_F^u)^{1-\gamma} = \theta \iff 1 + \tau_F = (1 - \tau_A)^{-\frac{\gamma}{1-\gamma}} \quad (28)$$

and the prices in Upstream are given by ¹¹

$$p_A^u = (1 - \tau_A) \theta F^{(1-\gamma)(1-\alpha)} \text{ and } p_F^u = (1 - \tau_A)^{-\frac{\gamma}{1-\gamma}} \theta F^{-\gamma(1-\alpha)}. \quad (29)$$

Notice that at the end of the period, Upstream has always an opportunity to not trade, in which case it's prices are the same as in autarky that we have solved for in Section 2.1. For Upstream to have an incentive to trade, it must hold that Upstream still has an incentive to specialize in A -good, i.e., it must hold that $w_A^u \geq w_F^u$.

Lemma 4 *Upstream never trades for $\tau_A > 0$ if it does not invest in technology, $\tilde{1}^c = 0$. If Upstream invests in technology, i.e., $\tilde{1}^c = 1$, then it is willing to trade as long as $\tau_A \leq \tau_A^{max}$, where*

$$\tau_A^{max} = 1 - \frac{1}{\bar{A}^{(1-\alpha)(1-\gamma)}}. \quad (30)$$

¹¹In reality, the Downstream country could choose the fees separately. However, if (28) would not hold then there would be an adjustment of the Upstream country's exchange rate. By considering all variables in the units of final good, we have taken such exchange rate adjustment already into account.

Proof. Suppose that Upstream did not invest and $w_A^u \geq w_F^u$. Then from (11) and (29) $(p_A^u)^{\frac{1}{1-\alpha}} \geq (p_F^u)^{\frac{1}{1-\alpha}} F \iff (1-\tau_A)^{\frac{1}{1-\alpha}} \theta^{\frac{1}{1-\alpha}} F^{(1-\gamma)} \geq (1-\tau_A)^{-\frac{\gamma}{1-\gamma} \frac{1}{1-\alpha}} \theta^{\frac{1}{1-\alpha}} F^{1-\gamma} \iff (1-\tau_A)^{\frac{1}{(1-\alpha)(1-\gamma)}} \geq 1$, which is a contradiction for any $\tau_A > 0$. Now suppose that Upstream invests. Then from (11) and (29), we obtain that $w_A^u \geq w_F^u$ if $(p_A^u)^{\frac{1}{1-\alpha}} \bar{A} \geq (p_F^u)^{\frac{1}{1-\alpha}} F \iff (1-\tau_A)^{\frac{1}{(1-\alpha)(1-\gamma)}} \bar{A} \geq 1 \iff 1 - \frac{1}{\bar{A}(1-\alpha)(1-\gamma)} \geq \tau_A$, which gives (30). ■

It is clear that the holdup problem is only relevant if Upstream invests in technology. The condition (30) also sets an upper limit on the fees that can be charged by Downstream. Any higher fees would imply that Upstream prefers autarky and Downstream does not earn any fee income. The maximum fees are higher if the potential improvement of technology in Upstream, $\bar{A}$, is larger.

Before addressing the optimal fees by Downstream and the conditions under which Downstream charges maximum fees, let us find the main outcomes in Upstream if it chose to invest in technology and $0 < \tau_A \leq \tau_A^{max}$.

Proposition 5 *Upstream invests in technology, $\tilde{I}^c = 1$, if*

$$I \leq I^u \equiv \alpha \Gamma \left(\bar{A} (1 - \tau_A)^{\frac{1}{1-\alpha}} - 1 \right). \quad (31)$$

If it invests in technology then consumption in Upstream is given by

$$C^u = \bar{C} + \Gamma \left((1 - \tau_A)^{\frac{1}{1-\alpha}} \bar{A} - 1 \right) + I^u - I, \quad (32)$$

imports are

$$(Y_F^u - \chi_F^u) = (1 - \gamma) (1 - \tau_A)^{\frac{1}{1-\gamma} + \frac{\alpha}{1-\alpha}} F^{(1-\gamma)\alpha} \alpha^{\frac{2\alpha}{1-\alpha}} \theta^{\frac{\alpha}{1-\alpha}} \bar{A} \quad (33)$$

and exports are

$$(\chi_A^u - Y_A^u) = (1 - \gamma) (1 - \tau_A)^{\frac{\alpha}{1-\alpha}} F^{\alpha(1-\gamma)} \alpha^{\frac{2\alpha}{1-\alpha}} \theta^{\frac{\alpha}{1-\alpha}} \bar{A}. \quad (34)$$

Proof. Given $l_A^u = 1$, the profit in the case of investment is from (10) and (29) given by $\pi_A^u(\bar{A}, F) = (1 - \alpha) \alpha \cdot \alpha^{\frac{2\alpha}{1-\alpha}} \bar{A} (1 - \tau_A)^{\frac{1}{1-\alpha}} \theta^{\frac{1}{1-\alpha}} F^{(1-\gamma)} = \alpha \Gamma \bar{A} (1 - \tau_A)^{\frac{1}{1-\alpha}}$, while for the case of no-investment it is $\pi_A^u(\bar{A}, F) = \alpha \Gamma$. From (29), (11), (10) in (8) we obtain that $C^u = (1 + \alpha) \Gamma (1 - \tau_A)^{\frac{1}{1-\alpha}} \bar{A} - I$. Using then (18) and (31), we obtain (32). From (27) the quantity imported is $(Y_F^u - \chi_F^u) = Y_F^u = \frac{p_A^u}{p_F^u} (\chi_A^u - Y_A^u) \implies p_F^u Y_F^c + p_A^u Y_A^c = p_A^u \chi_A^u$. At the same time we know that by (12) it also holds that $p_F^u Y_F^c + p_A^u Y_A^c = \frac{1}{1-\gamma} Y_F^u p_F$. Therefore, $Y_F^u = (1 - \gamma) \frac{p_A^u}{p_F^u} \chi_A^u$. Using (29) and (9), we obtain that imports are $(Y_F^u - \chi_F^u) = Y_F^u = (1 - \gamma) \frac{p_A^u}{p_F^u} \chi_A^u = (1 - \gamma) \alpha^{\frac{2\alpha}{1-\alpha}} \theta^{\frac{1}{1-\alpha}} (1 - \tau_A)^{\frac{1}{1-\gamma} - \frac{1}{1-\alpha}} F^{1-\gamma} \bar{A}$ which gives (33). The value of export follows from current account $(\chi_A^u - Y_A^u) = \frac{p_F^u}{p_A^u} (Y_F^u - \chi_F^u)$ and prices (29). ■

Comparing Proposition 7 with Lemma 4, we can see that any positive fees charged by Downstream will reduce the range of values of I at which it is optimal for Upstream to invest in technology. Therefore, a potential holdup problem reduces the likelihood that Upstream will develop a comparative advantage. If Upstream does invest, then both consumption and imports are still lower than in the case of free trade. If fees are smaller than the maximum fees, then the average consumer in Upstream is better off in the case of trade than in the case of autarky.

We can now explore the optimal fees. Assume that Upstream has invested in technology. Downstream knows how the volume of exports and imports depends to τ_A (see (33) and (34)). Using also (22), (26) and (28), the optimal fees must solve

$$\max_{\tau_A} T_v^d = \left((1 - \gamma) \alpha^{\frac{2\alpha}{1-\alpha}} \theta^{\frac{1}{1-\alpha}} \bar{A} F^{(1-\gamma)} \right) \cdot (1 - \tau_A)^{\frac{1}{1-\alpha}} \left(1 - (1 - \tau_A)^{\frac{1}{1-\gamma}} \right), \text{ s.t., } \tau_A \leq \tau_A^{\max}. \quad (35)$$

Proposition 6 *The optimal fee charged by Downstream is*

$$\tau_A^v = \begin{cases} \tau_A^* = 1 - \left(\frac{\alpha - \alpha\gamma}{1 - \alpha\gamma} \right)^{1-\gamma} > 0 \text{ if } \tau_A^* \leq \tau_A^m \\ \tau_A^{\max} \text{ if } \tau_A^* > \tau_A^m \end{cases} \quad (36)$$

Proof. As the first term in (35) is a constant, the equivalent problem is $\max_{\tau_A} \ln(T_v^d) =$

$\frac{\alpha}{1-\alpha} \ln(1 - \tau_A) + \ln\left(1 - (1 - \tau_A)^{\frac{1}{1-\gamma}}\right)$. As $\ln(T_v^d)$ is concave τ_A ,¹² we obtain that if the constraint $\tau_A \leq \tau_A^{\max}$ is not binding, then the first order condition gives that $\frac{\partial \ln(T_v^d)}{\partial \tau_A} = -\frac{\alpha}{1-\alpha} \frac{1}{1-\tau_A} + \frac{1}{1-\gamma} \frac{1}{(1-\tau_A)} \left((1 - \tau_A)^{-\frac{1}{1-\gamma}} - 1\right)^{-1} = 0 \iff \tau_A = \tau_A^*$ as given in (36). If $\tau_A^* > \tau_A^m$, then Downstream charges maximum fees such that Upstream is indifferent between autarky and trading. ■

Proposition 6 implies that Downstream always charges positive fees. As long as the optimal fee is not the maximum one, i.e. $\tau_A^v \leq \tau_A^m$, it does not depend on the quality of technology in Upstream. This is because better quality of technology proportionally increases both exports and imports of Upstream. At the same time, from (35) it is clear that the fee income for Downstream is higher if the technology is better. From (30) and (36) $\tau_A^* \leq \tau_A^m$ holds if and only if the quality of technology is sufficiently high, i.e. $\bar{A} > \left(\frac{1-\alpha\gamma}{\alpha-\alpha\gamma}\right)^{\frac{1}{(1-\alpha)}} > 1$. Together with Proposition 7, this implies that if there is large enough improvement in technology, Upstream is strictly better off trading than in autarky, but still less well off than in the absence of the holdup problem.

Finally, if the improvement in technology is relatively small, then the possibility of a holdup problem can lead to a situation where Upstream and Downstream are both weakly worse off compared to free trade. Namely, if the cost of investments is such that $I^u < I < I^{\text{free_trade}}$, Upstream does not invest in technology and Downstream does not benefit from the fees. If such a situation arises Downstream would benefit from committing to lower fees through a trade agreement, such that Upstream still has an incentive to develop a comparative advantage and trade. However, such commitment may not be possible as Downstream would have an incentive to renegotiate the fees after Upstream has already made the sunk investments. We now consider another mechanism that can partially mitigate the holdup problem - ownership of firms in Upstream by the investors in Downstream.

¹² $\frac{\partial^2 \ln(T_v^d)}{\partial^2 \tau_A} = -\frac{\alpha}{1-\alpha} \frac{1}{(1-\tau_A)^2} - \frac{1}{1-\gamma} \left(\frac{\gamma}{1-\gamma} (1 - \tau_A)^{-\frac{1}{1-\gamma}} + 1\right) (1 - \tau_A)^{-2} \left((1 - \tau_A)^{-\frac{1}{1-\gamma}} - 1\right)^{-2} < 0$ for any $0 < \tau_A < 1$

2.3 Holdup and foreign ownership of firms

So far, we assumed that firms investing in technology are always owned by local agents. The fees charged by Downstream directly affect incentives of firms in Upstream to invest in technology. These firms know that there will be less demand for capital by the specialized good's sector A , because this sector will sell its' good to the world market at lower price due to the holdup problem. Therefore, the profits and the stock price of technology firms, is directly affected by Downstream's trade policy. Under capital mobility, this creates a potential relationship between trade conditions and ownership of the firms. For this mechanism to be interesting, we assume throughout this section that $\bar{A}$ is sufficiently high such that the optimal fees are below the maximum fees Downstream can charge, i.e. $\tau_A^* < \tau_A^m$.

While it is not crucial, we assume that investors from Downstream make takeover offers after the technology investments has been made, but before the optimal variable fees are chosen by the government of Downstream.

In this setting, consumption per capita in Upstream is

$$\tilde{C}^u = w^u + \tilde{P}_\pi^u - I \quad (37)$$

and in Downstream is

$$\tilde{C}^d = C^{exo} + \left(\tilde{\pi}_2^u - \tilde{P}_\pi^u \right) + \tilde{T}_v^d, \quad (38)$$

where $\tilde{P}_\pi^u$ is the price that the investors of Downstream pay for the technology firm in Upstream. $\tilde{\pi}_2^u$ is the profit of Upstream firm when owned by investors from Downstream and $\tilde{T}_v^d$ is the fee income in such case. We also expressed that consumption in Downstream county that arises from other unrelated sources as C^{exo} (see also footnote 9).

The optimal fees that maximize consumption in Downstream then solve

$$\tilde{\tau}_A^* = \arg \max_{\tilde{\tau}_A} \left(\tilde{T}_v^d + \tilde{\pi}_2^u \right), \text{ where } \tilde{T}_v^d \text{ is given by (35) for } \tau_A = \tilde{\tau}_A. \quad (39)$$

If the technology firm in Upstream is owned by local investors, then from (10), (29) and definition (20) the profits in this firm are $\pi^u = \alpha\Gamma\bar{A}(1 - \tau_A^*)^{\frac{1}{1-\alpha}}$, where τ_A^* is given by (36). If it is owned by investors from Downstream, the profits are $\tilde{\pi}_2^u = \alpha\Gamma\bar{A}(1 - \tilde{\tau}_A)^{\frac{1}{1-\alpha}}$.

We can guess and verify that the optimal fees in the latter case are lower, $\tilde{\tau}_A^* < \tau_A^*$. If this holds, then the profits are higher, if the firm is owned by investors from Downstream, i.e. $\tilde{\pi}_2^u > \pi_2^u$. Technology producers in Upstream are willing to sell their firm for a price that is at least π_2^u . Investors from Downstream are willing to buy the firm at most $\tilde{\pi}_2^u$. From here the equilibrium equity price must be between these two prices, i.e. $\tilde{P}_\pi^u = \beta\tilde{\pi}_2^u + (1 - \beta)\pi_2^u$, where $\beta \in [0, 1]$ measures the intensity of competition between the potential investors from Downstream.

Proposition 7 *If investors from Downstream own the firm in Upstream, then there is a unique solution for optimal fees $\tilde{\tau}_A^*$, such that*

$$\tilde{\tau}_A^* < \tau_A^*.$$

Proof. See Appendix B.5. ■

Downstream government takes the business interests of its residents into account which lowers the fees. From (33) and (34), it increases the volume of imports and exports between Upstream and the rest of the world. It also increases both the likelihood of technology investments and consumption in Upstream.

Proposition 8 *Investment in technology pays off in Upstream if*

$$I < \tilde{I}^u = I^u + \beta\alpha\Gamma\bar{A}\varphi \tag{40}$$

and the consumption there is

$$\tilde{C}_v^u = C^u + \Gamma\bar{A}\varphi + \beta\alpha\Gamma\bar{A}\varphi, \tag{41}$$

where $\varphi \equiv \left((1 - \tilde{\tau}_A^*)^{\frac{1}{1-\alpha}} - (1 - \tau_A^*)^{\frac{1}{1-\alpha}} \right) > 0$ and $\tilde{I}^u$ and C^u are defined in (31) and (32).

Proof. See Appendix B.6. ■

Lemma 8 shows that Upstream always benefits from foreign ownership of its' technology firm. First, lower fees imply higher wages for local consumers. Furthermore, if Downstream investors compete ($\beta > 0$), then consumers in Upstream also benefit from selling their firms for a higher value than otherwise. In such a case, also the investments in technology are more likely as the threshold for the profitable investments is higher (see (40)). This is an example of a situation, where the reason why investments are more likely under foreign ownership is not the standard reason that foreign owners bring knowledge, but it is purely due to interaction between identity of the investor and trade policy - government in Downstream optimally charges lower fees to benefit its' agents business interests (and its residents' consumption).

While consumers in Downstream receive lower revenue from the fees, the returns they receive from owning the firm in Upstream can compensate for this. The crucial parameters that determines whether consumers in Downstream benefit or lose from owning firms in Upstream is the bargaining power of takeover investors in Downstream, β .

Lemma 9 *There exists a threshold $\bar{\beta}(\alpha, \gamma) < 1$ such that the consumers in Downstream are better off due to ownership of firms in Upstream.*

Proof. See Appendix B.7. ■

Figure 3 plots the threshold value of bargaining power, $\bar{\beta}(\alpha, \gamma)$, that guarantees gains for consumers in Downstream. While the relationship is non-monotonic, the likelihood of gains tends to be higher if the A-good is more valuable for the final goods sector, i.e. γ is high. Also, the threshold $\bar{\beta}(\alpha, \gamma)$ is always positive¹³ and there is a price for which selling the technology producing firms to Downstream investors benefits both countries.

While Downstream may lose due to its firms investing in Upstream, it can use additional policy instruments to avoid this. For example, it can impose a tax on the profits its investors

¹³As $\bar{\beta}(\alpha, \gamma)$ is determined only by $\alpha \in (0, 1)$ and $\gamma \in (0, 1)$, Figure 2 exhaust the possible outcomes (it considers all values in the range from 0.01 to 0.99 for both parameters).

Figure 2: The threshold for the bargaining power $\bar{\beta}(\alpha, \gamma)$ that guarantees consumption gains for the downstream country.

earned from abroad and distribute it as a lump sum transfer to consumers, i.e. it could impose a tax $\lambda \tilde{\pi}_2^u$ where $\lambda \in (0, 1)$. In this case, the price of firms in Upstream must be between π_2^u and $\lambda \tilde{\pi}_2^u$. Setting the tax $\lambda \geq \bar{\beta}(\alpha, \gamma)$, would guarantee that investors in Downstream do not buy these firms "too expensively".

3 Implications of the model and trade patterns.

The model suggests that while trade increases income and the probability of investments in technology, a country that faces a holdup problem is poorer and less likely to invest in technology and to trade. If such country trades, then also the trade volume is smaller. An immediate example of countries that are likely to face a holdup problem are landlocked countries.

In the empirical part we will focus on the bilateral import data. Recall the equations (25) and (33) that describe the imports between two countries that do not and do face a

holdup problem respectively. Taking logs, we obtain that

$$\ln(Y_F^u - \chi_F^u) = \begin{cases} \ln\left((1-\gamma) F^{(1-\gamma\alpha)} \alpha^{\frac{2\alpha}{1-\alpha}} \theta^{\frac{\alpha}{1-\alpha}} \bar{A}\right) & \text{if there is no holdup} \\ \ln\left((1-\gamma) F^{(1-\gamma\alpha)} \alpha^{\frac{2\alpha}{1-\alpha}} \theta^{\frac{\alpha}{1-\alpha}} \bar{A}\right) + \left(\frac{1}{1-\gamma} + \frac{\alpha}{1-\alpha}\right) \ln(1-\tau_A) & \text{if there is holdup} \end{cases} \quad (42)$$

To bring these prediction to data we also need to include exogenous transport costs which depend on distance. The difference between transport costs and fees due to holdup is that the latter are policy variables and should not affect trade between countries that trade directly (e.g. neighbors or both not landlocked). It would be straightforward to augment the model with physical trading costs (e.g., iceberg costs) that proportionally reduce the imports. A general relationship suggested by the model is that log imports are determined by three types of variables terms

$$\ln(\text{imports}) = \text{country_pair_characteristics} + \text{transport_cost} + \text{holdup_cost} \quad (43)$$

Based on this, we test three implications of the model.

The effect of the potential for holdup on trade

The above implies the following testable relationship for imports to country i from country j (potentially through country k).

$$\ln(\text{imp})_{i,j,t} = E[\alpha X_{i,j,t} + \beta \tilde{\tau}_{T,t} + \gamma HU_{ij}], \quad (44)$$

where $X_{i,j,t}$ represents country characteristics of trading partners and $\tilde{\tau}_{T,t}$ represent transportation and other trading costs. HU_{ij} finally is a dummy that takes the value 1 when trade between countries i and j is subject to a potential holdup problem.

$$HU_{ij} = \begin{cases} 0 & \text{if no transit country needed for } i \text{ to trade with } j \\ 1 & \text{if trade between } i \text{ and } j \text{ has to pass a transit country} \end{cases}$$

For example, for a landlocked country HU_{ij} is 1 for all trading partners except trade with its neighbors. Potential fees due to holdup would be present if a country trades through another territory and based on our model (see (42)) we expect $\gamma < 0$.

Do trade agreements reduce the holdup problem?

To examine if trade agreements with transit countries alleviate a potential holdup problem we estimate

$$\ln(imp)_{i,j,t} = E[\alpha X_{i,j,t} + \beta \tilde{\tau}_{T,t} + \gamma HU_{ij} + \delta HU_{ij} \cdot TA_{ijkt}], \quad (45)$$

where TA_{ijkt} is 1 if there is a trade agreement between country i and its transit country and/or there is a trade agreement between country j and its transit country. Based on the model we expect $\gamma < 0$ and $\delta > 0$. We use membership of both the trading country and the transit country in WTO or if they have a free trade area to define TA_{ijkt} . We also look at Europe, that has a history of trade agreements between the member countries of European Community and EFTA. Within this group we expect the holdup problem may be smaller or absent.

Does foreign ownership reduce the holdup problem?

As argued in Section 2.3, foreign ownership of assets in Upstream is expected to reduce the holdup fees. We therefore estimate

$$\ln(imp)_{i,j,t} = E[\alpha X_{i,j,t} + \beta \tilde{\tau}_{T,t} + \gamma_i HU_i + \gamma_j HU_j + \gamma_{F,j} HU_j \cdot FDI_liab_j + \delta_j FDI_liab_j], \quad (46)$$

where HU_i is 1 if the importer i faces a holdup problem in its trade with j and HU_j is the corresponding dummy for the exporter j . Foreign direct investment liabilities by j are given by FDI_liab_j and it would be consistent with the model if $\gamma_j < 0$ and $\gamma_{F,j} > 0$.

3.1 Data

To examine the predictions of the model we examine an unbalanced panel of the value of imports of 152 countries measured at 5 year intervals between 1950 and 2000. The import data are from IMF's direction of trade statistics and expressed in constant 1982-83 US dollars. Our baseline regression is a standard gravity regression with $X_{i,j,t}$ including for importer i and exporter j at time t : time dependent importer and exporter fixed effects, bilateral distance, number of islands in trading relation, as well as dummies capturing common language, common colonizer, former colonial relation, current colonial relation, currency union membership, free trade agreement, if imports to industrial country i from country j are covered by the generalized system of preferences and one/both in WTO. The variables above are from Subramanian and Wei (2007), who in turn build on Rose (2004). In some specifications we use foreign direct investment liabilities as an explanatory variable, these are from Lane and Milesi-Ferretti (2007).

We follow Subramanian and Wei (2007) and use time dependent exporter and importer fixed effects in our main specification. As stressed by Anderson and van Wincoop (2004) bilateral trade volume depends not only on bilateral trade costs, but also on the trade costs vis-à-vis all other trading partners. As shown in Feenstra (2004) exporter and importer fixed effects can be used to control for the impact of these relative barriers. Any country specific variable that does not vary across trading partners (such as aggregate productivity, number of potential transit countries, quality of institutions or a dummy for landlocked status) will be collinear with the fixed effect (see also equations (42) and (43)). Thus, country fixed effects will capture the effect of being landlocked on imports. The holdup dummy will be identified by that for a landlocked country trade with its neighbors will not be subject to a holdup problem. In robustness checks, in Table 3, we also estimate gravity equations without these fixed effects using products of GDP's and GDP's per capita as additional explanatory variables, as in the model, we can show that the country pair variables are proportional to the final good output]. The main new feature of the data is how distance is measured, as

explained in the following.

3.1.1 Measuring distance.

We use distances between main cities in our main specification (using the classification of main cities from CEPII (Mayer and Zignago (2006))) We measure distances between adjacent countries by great circle distance ("as the crow flies"). For other trading relations we add distances from the main cities to their closest main ports (data from www.findaport.com) and thereto add distance between ports (data from www.portworld.com). We use this measure of distance as shipping by sea is the dominant mode of trade for non-adjacent countries (Hummels (2007)). Using dots to denote main cities and triangles to denote ports Figure 2 illustrates the distance measure between Country B and three other countries.

Figure 2: Illustration of measurement of distances.

Our use of distances via ports set us apart from other articles in the gravity literature that have typically relied on great circle distances between countries. However, as we are particularly interested in the holdup problem, and trade patterns of landlocked countries, using great circle distance is associated with a potential measurement error. To all trading partners, apart from neighbors, the distance of a landlocked country to trading partners

Bilateral distances between coastal countries or countries that share a land border (holdup=0).			
	Sea+land, main cities	Great circle, main cities	Great circle, midpoints
Sea+land, main cities	1.000		
Great circle, main cities	0.874	1.000	
Great circle, midpoints	0.858	0.989	1.000
Bilateral distances where there is at least 1 transit country (holdup=1).			
	Sea+land, main cities	Great circle, main cities	Great circle, midpoints
Sea+land, main cities	1.000		
Great circle, main cities	0.805	1.000	
Great circle, midpoints	0.789	0.992	1.000

The table reports correlations between distances. Main cities as defined as in CEPII-data, (www.cepii.fr). Sea+land via closest port (great circle distance is used for countries sharing a land border) and great circle distances between midpoints as in Rose (2004) and Subramanian and Wei (2007).

Table 1: Correlations between different measures of distance.

is greater than that of its transit country - something we would not capture with great circle distances.¹⁴ We use Figure 3 to illustrate the implication of this for distance and trade of landlocked countries.¹⁵ Consider trade between landlocked country LL and country B. Trade between these countries will want to go the shortest way overland and thus pass via country A and be subject to a potential holdup problem. Compare to trade between country A and country B on the other hand - using great circle distances will assign a shorter bilateral distance between LL and B than between A and B. Consider a case where there was no holdup problem and where actual distances travelled by goods decrease trade: We would then erroneously conclude that trade between country LL and B was lower because of a holdup problem when mismeasurement of distance would be the culprit. The distance measure that we use allows for distance to have a more depressing effect on trade when it is overland and in our regression we include the share of distance that is overland as a regressor.

¹⁴Depending on what point in a country one uses to measure distances to and from this need to always hold. For instance the capital of a landlocked country may be closer to the sea than the capital of its coastal neighbor if the coastal country's capital is far enough inland.

¹⁵Black dots denote main cities and shaded dots ports. Thin dotted lines show distance on land and fat dotted lines show distance by sea.

In Table 1 we report the correlation between bilateral distances measured between main cities via the closest port, great circle distances between main cities and great circle distances between midpoints of countries. As seen, the correlation between distances via ports and the other distance measures is considerably lower (in all cases less than 0.9) than the correlation between the two great circle measures (0.99). The correlation between the distance via ports and great circle distance is lower if the trading relation is subject to a holdup problem: falling from around 0.86 to around 0.8¹⁶ This is an indication that the mismeasurement issue discussed above may affect the interpretation of the holdup dummy and we therefore use sea and land distances as our main distance measure.

3.2 Results from regressions

In Table 2 we report the results from estimating eq (44). We first examine a baseline regression and compare different measures of distance. Column 1 reports results from a standard gravity model using great circle distance between country midpoints. We use a slightly different set of covariates than Subramanian and Wei (for instance the holdup dummy and the number of islands in the trading relation) - nevertheless our baseline results are very similar to theirs, for instance their coefficient on distance is -1.259 (Table 6, column 1) compared to ours of -1.226. Column 2 uses great circle distances between main cities and column 3 reports the regression with distance measured as distance via closest ports. Our main interest is on the coefficient on the holdup dummy and we now focus our discussion on this coefficient across the specifications. Using the estimate in column (3) the coefficient on holdup indicates that imports of a country from a partner are some 66 percent ($\exp(0.512)-1$) lower if their bilateral trade is subject to a holdup problem. Differences between regressions in the magnitude of the holdup dummy are minor and thus the lower trade of a landlocked country associated with our holdup dummy is not driven by mismeasurement of distance.

¹⁶Using a t-test and Fischer's r to z transformation we can reject in each case that the correlations between sea+land distance and great circle distances are the same for the trading relations subject to holdup and those that are not.

Variable	(1) ln(imp)	(2) ln(imp)	(3) ln(imp)	(4) ln(imp)	(5) ln(imp)	(6) ln(imp)
Distance measure	Gr. circle, mid points	Gr. circle, main city	Sea+Land, main city	Sea+Land, main city	Sea+Land, main city	Sea+Land, main city
Ln(distance)	-1.226*** (0.0233)	-1.160*** (0.0242)	-1.154*** (0.0340)	-1.375*** (0.0401)	-0.952*** (0.104)	-0.643*** (0.0528)
Share of land in dist.			0.00754 (0.403)	-0.449 (0.418)	0.672 (0.674)	-0.112 (0.593)
Holdup	-0.494*** (0.0995)	-0.585*** (0.0953)	-0.512*** (0.104)	-0.594*** (0.110)	-0.518*** (0.155)	0.0650 (0.103)
Land border	0.0465 (0.109)	0.123 (0.112)	-0.313** (0.135)	-0.253 (0.164)	0.538** (0.244)	-0.649*** (0.236)
Sample	Full	Full	Full	1990-2000	Africa	Europe
Time var FE	yes	yes	yes	yes	yes	yes
Obs.	71614	71614	71614	30435	15426	21748
Root MSE	1.656	1.659	1.666	1.761	1.942	1.123
Adj. R ²	0.736	0.735	0.732	0.747	0.648	0.870

Notes: All regressions include time varying exporter and importer fixed effects. In addition all regressions include a constant and controls for common language, common colonizer, former colonial relation, current colonial relation, currency union membership, number of islands in trading relation, free trade agreement, trade covered by generalized system of preferences, one/both in WTO. Standard errors clustered at country pair.

**** significant at 1 percent, *** at 5 percent and ** at 10 percent

Table 2: Bilateral trade in a gravity framework, 1950-2000.

Nevertheless, the distance over sea and land is the one that matches our model the closest and we use this distance measure in the following analysis.

Conceivably, holdup may have been a problem in the earlier parts of the period but increasing accession to the GATT/WTO and the more liberal trading order may have muted the holdup concerns. In column 4 we therefore examine the period 1990 and after - the coefficient on holdup is still significant and of similar magnitude. The first prediction from the model is thus supported and it is not only a historical problem. Many of the poorest landlocked countries are located in Africa and arguably institutional arrangements to protect from holdup issues are weaker there than elsewhere. In column (5) we therefore examine trade flows where the exporter is an African country, the coefficient is similar as when we estimate on the whole sample. On the other hand one may argue that the potential for holdup is much less severe in Europe, where in particular the European Community and later the European Union should imply an important restriction on the possibility of holdup by transit countries. Indeed when we only examine European exporters the point estimate on the holdup dummy is close to zero and not significant.

The coefficient on the share of land in distance is typically not significant in Table 2. This lack of significance surprised us - note though that for most trading relations this share is low and the exporter and importer fixed effects will be picking up much of the variation in the share of land in distance. As in the specifications of Subramanian and Wei (2007) the border coefficient is not significant in columns (1) and (2). The coefficient on sharing a land border is significantly negative when we use the sea and land distance measure for the full sample and for European exports. This may be partly reflecting that we measure distance between land neighbors by great circle rather than via ports - which will assign a lower distance between land neighbors than between otherwise equidistant trading partners. Given this, and that we control for a host of variables that are frequently correlated across neighbors (such as common language) the negative effect of a land border is less surprising. Given the wealth of controls in addition to time varying fixed effects for each exporter and importer it is also

clear that multicollinearity could produce somewhat unstable results across specifications. We note however that the coefficient of interest - the holdup dummy - is remarkably stable across specifications.

In Table 3 we first explore if trade agreements with transit countries and foreign direct investment can neutralize the holdup problem. Using time-varying exporter and importer fixed effects would leave no variation for FDI liabilities and little for trade agreements with the transit country to explain. As in Rose (2004), we therefore replace time varying fixed effects with time effects and the products of GDP's and GDP's per capita of the importing and exporting countries in columns (1)-(5). Column (1) reports our baseline regression estimated this way. As seen in column (1) the main coefficient of interest is still negative and significant with a point estimate of -0.309. Column (2) reports the results from an estimation of eq. (45). The point estimate on the interaction between the holdup dummy and free trade agreements with transit countries is positive - which would suggest that trade agreements alleviate the holdup problem. However the point estimate is low and not statistically significant. In column (3) we only examine the period after 1990 but the point estimate is still low and not significant.¹⁷ There is thus little indication that trade agreements with transit countries are effective in solving the holdup problem. To understand this result note that many of the African landlocked countries, and their transit countries, became members of GATT already in 1963. Many other landlocked countries are late joiners to WTO/GATT (Bolivia (1990), Paraguay (1994), Mongolia (1997), Nepal (2004), Laos (2013)). With the weak institutions that plague many African countries it perhaps not surprising that trade agreements have not been an effective remedy against fears of ex post opportunistic behavior.

Our model predicts that ownership by the transit country is a way to solve the holdup problem. It is difficult to find reliable data on bilateral foreign direct investment liabilities for the landlocked countries that are our prime focus. In a richer setting ownership by large foreign corporations would also work to limit the holdup problem and we therefore

¹⁷Note that the set of landlocked countries is expanded in the later years when the Soviet Union dissolves.

Variable	(1) Ln(imp)	(2) Ln(imp)	(3) Ln(imp)	(4) Ln(imp)	(5) Ln(imp)	(6) Ln(imp) Probit	(7) Ln(imp) Heckman	(8) Ln(imp) 100bin (HMY)
Ln(distance)	-0.975*** (0.0280)	-0.974*** (0.0280)	-1.148*** (0.0339)	-1.177*** (0.0353)	-1.204*** (0.0350)	-0.267*** (0.0143)	-1.396*** (0.0406)	-1.113*** (0.0415)
Share of land in dist.	0.604* (0.320)	0.602* (0.320)	0.0334 (0.374)	-0.503 (0.384)	-0.484 (0.384)	-0.712*** (0.140)	-0.388 (0.416)	0.109 (0.394)
Holdup (HU)	-0.309*** (0.0428)	-0.321*** (0.0457)	-0.403*** (0.0524)			-0.0973*** (0.0292)	-0.563*** (0.110)	-0.431*** (0.100)
Land border	0.111 (0.120)	0.111 (0.120)	0.350** (0.148)	0.213 (0.157)	0.172 (0.155)	-0.103 (0.0692)	-0.139 (0.164)	-0.0238 (0.151)
HU*fta		0.0436 (0.0512)	0.0543 (0.0599)					
HU_imp				-0.205*** (0.0513)	-0.299*** (0.0552)			
HU_exp				-0.395*** (0.0549)	-0.374*** (0.0549)			
HU_exp × FDI/CAP					0.0128** (0.00620)			
FDI/CAP					0.0351*** (0.00233)			
Common language	0.332*** (0.0431)	0.332*** (0.0431)	0.493*** (0.0514)	0.539*** (0.0570)	0.543*** (0.0537)	0.118*** (0.0122)		
Inverse Mills ratio							0.0246 (0.225)	
Sample	Full	Full	1990-2000	1995-2000	1995-2000	1990-2000	1990-2000	1990-2000
Time var FE	no	no	no	no	no	yes	yes	yes
Obs.	69481	69481	28302	18347	18347	54098	29905	29905
Adj. R ²	0.637	0.637	0.671	0.689	0.694	0.579	0.731	0.741
Root MSE	1.943	1.943	2.026	1.908	1.890	Pseudo R ²		
							1.786	1.755

Notes: Columns (1-5) include year fixed effects product of GDPs and product of GDPs per capita. In addition, all regressions include a constant and controls for common colonizer, former colonial relation, current colonial relation, currency union membership, free trade agreement, generalized system of preferences, number of islands in trading relation, one/both in WTO. Columns (6-8) include time varying exporter and importer fixed effects instead of time effects. Column (6) reports marginal effects. Column (8) uses predicted probabilities from (6) sorted into bins following Helpman, Melitz and Rubinstein (2008). Distance measure is sea+land between main cities in all specifications. Standard errors clustered at country pair. "****" significant at 1, "***" significant at 5, and "*" significant at 10 percent.

Table 3: Bilateral trade in a gravity framework. The role of trade policy, foreign direct investment and the extensive margin.

use FDI liabilities per capita for the exporter which we interact with the holdup dummy as in (46). As a benchmark, column (4) examines the holdup dummies for the exporter and importer separately for the set of trade relations where we have FDI per capita figures for the exporter. Trading through a transit country is associated with lower trade for both importer and exporter. In column (5) we introduce FDI per capita for the exporter and interact it with the holdup dummy. Higher levels of FDI per capita is associated with more trade and the coefficient on the interaction with the holdup dummy indicates that the holdup problem is attenuated by higher foreign direct investments - a finding consistent with the model. Evaluated at the means for FDI per capita (8.03) the positive effect of FDI per capita for a landlocked country is to increase trade by 11 percent ($\exp(0.0128 \cdot 8.03) - 1$). As always, caution is advised in drawing conclusions from cross-country regressions. We nevertheless note that the empirical evidence is consistent with our expectations for the holdup dummy and the effect of foreign ownership.

One concern, in line with our model, is that some trading relationships are not established as a consequence of holdup problems. Helpman, Melitz and Rubinstein (2008) bring the prevalence of zero trade flows between possible trading partners to the fore. We therefore expand the dataset to consider all possible trading relations. Including the zero trade flows roughly doubles the data set and to limit the computational burden we focus on the period 1990 to 2000. In column (6) we report the marginal effects from a probit regression where the dependent variable is 1 if country i imports from country j in period t and 0 otherwise. The explanatory variables are the same as in our baseline specification, including time varying exporter and importer fixed effects. A change in the holdup dummy from 0 to 1 is associated with a 10 percent lower probability of two countries trading in the specification in column (6). A higher share of land in distance is associated with a lower probability that two countries trade. Going from the 1st (0 landshare) to the 99th percentile (a landshare of 0.42) is associated with a 30 percent lower probability of a positive trade flow ($-0.71 \cdot 0.42$).

We are interested in using the predicted probabilities in second stage regressions and we

therefore want to include some variable that affects the probability of trade, but not the volume, once we have controlled for the probability. Helpman, Melitz and Rubinstein (2008) find that common language is an attractive candidate for such a variable and we follow their lead in this. Column (7) presents the second stage of the Heckman estimation technique for correcting for sample selection bias. It is the baseline regression, excluding common language but including the Mills ratio which is calculated using the first stage probit results in column (6). The relevant comparison is with the baseline regression, not correcting for sample selection, that we report in column (4) of Table 2. As in Helpman, Melitz and Rubinstein (2008) the coefficients on the coefficients of interest are little affected by the sample selection adjustment - indeed the coefficient on the inverse Mills ratio is not significant. Helpman, Melitz and Rubinstein (2008) show how sorting the predicted probabilities from a first stage probit estimation (column 6) into equal sized bins and including indicator variables for these bins is a flexible way of controlling for the probability of observing a trading relation. As do they, we find that this way of controlling for the probability of observing an import relation results in a fall in the coefficients measuring trade frictions. For our purposes we note that the holdup dummy, even though lower, is still highly significant and in the same range as in our 1990-2000 benchmark in Table 2, column (4).

In sum, we find that having trade go through a transit country is associated with a large depressing effect on trade which, depending on specification, ranges between roughly 50 ($\approx \exp(0.431) - 1$ from column 8 in Table 3) to 80 percent ($\approx \exp(0.599) - 1$ from column 4 in Table 2) in specifications where we include importer and exporter fixed effects. This effect is not a result of a potential under-reporting of distance for landlocked countries as we use a new measure of distance that arguably better captures the relevant distances involved in trade of landlocked countries. The exception to the negative and significant impact of our holdup dummy is European exports - our preferred interpretation is that institutional arrangements in Europe have succeeded in solving the holdup problem (on average - exceptions can clearly be found as illustrated by severe controversies in 2008-2009 regarding the conditions under

which Ukraine is willing to let Russian gas reach final customers in western and central Europe). Trade agreements and WTO membership of transit countries elsewhere appear not to have been effective remedies against the holdup problem but the data are consistent with the notion that higher FDI liabilities are associated with less of a holdup problem.

4 Concluding remarks

The trade of a landlocked country must pass a transit country to reach world markets. The transit country is thus given an opportunity to dictate the terms by which the landlocked country trades - in our model this makes the landlocked country poorer than it would be under free trade. Furthermore, the trade volume and gains from technology investments are smaller if a country is subject to a holdup problem. Foreseeing this we are less likely to see technology investments in the landlocked country. As long as there is a lack of models and rigorous discussion about these issues it makes them less likely to be incorporated into international policy efforts to improve the situation in landlocked countries. For example, in a 2003 conference organized by the United Nations a set of measures were agreed on (the Almaty declaration) to better the situation for landlocked countries. Most of the suggestions focused on trade facilitation and better infrastructure - holdup type problems were not given a prominent role. By focusing on the potential for holdup, rather than high shipping costs per se, our model points to the importance of arrangements to generate commitment to secure transit. Internationally supervised "transport corridors" may for instance be one way of making it more certain that a landlocked country which adjusts its industrial structure to benefit from international trade also gets to reap the gains of that investment.¹⁸

A brief look at world history points to an important role for the type of concerns that we examine. Indeed, mercantilist economic thought that long dominated Europe was pre-occupied with issues of (bargaining) strength. That coastal nations such as the UK, with

¹⁸For a thorough overview of the current status and history of legal rules regarding the transit rights of landlocked countries see Uprety (2006).

unhindered access to the developing overseas markets, were among the first to adopt more liberal trade policies is clearly in line with the model (see for instance Irwin (1996)). The empirical evidence that we present is consistent with the idea that these concerns are not only of historical importance. We have attempted to make the model as simple and transparent as possible and many extensions are possible that may add more realism. In some cases, such as with Switzerland, geography and history may also have endowed the landlocked country with some countervailing bargaining power by control over important overland routes. Furthermore, a landlocked country may have several potential ways to access world markets. In the current model all bargaining power is given to Downstream. An alternative route to world markets would act as an outside option for Upstream - holdup concerns would still be relevant but the rents that Downstream could extract would be lower. The better outside options that a landlocked country has, the less severe will the holdup problems be. A realistic model would include important frictions, such as the possibility of collusion between two downstream powers and infrastructure investment. Nevertheless, the main mechanisms analyzed would remain valid in a more general setting as long as the monopolistic or oligopolistic power of transit countries (or ports) can not be fully eliminated.

Finally, the empirical analysis is done at an aggregated level, only examines some implications of the theory and many refinements are possible. A key prediction of the model is that landlocked countries are less likely to export products that require a sunk cost of investment. In exploratory work using data from 2000 we compared exports across coastal and landlocked countries. We found that, outside Europe, landlocked countries export a lower share of commodities that are more likely to require high up-front investments, such as products requiring specialized suppliers, large scale or science-based inputs. Also, as suggested, by our model the share of differentiated products in exports is lower for landlocked countries outside Europe.¹⁹ For more recent times one can also examine the degree of specialization

¹⁹Trade data for 2000 (at 4-digit level) from NBER/UN as reported in Feenstra et al (2005). The classification of 4-digit products to different types of commodities follows OECD (1994). For the share of exports that are differentiated we use the Rauch ("liberal") classification.

in goods that are relatively economical to transport by air. Rather than pursue this further in this paper we note that the perhaps cleanest way to understand the relative roles of holdup and transport costs would be to compare the production structure of inland regions of coastal countries to neighboring regions in landlocked countries. This, and the qualitative and quantitative effects in a more elaborate setting, is left for future research.

A Proofs in the theoretical part

A.1 Proof of Lemma 1

The first order condition of (3) gives that the wage in sector J solves $w_J = (1 - \alpha) \frac{p_J^i \chi_J^i}{L^i l_J^i}$ and the demand curve for the capital good is $p_{x,J}^i = \alpha p_J^i \left(\frac{l_J^i L^i J^i}{x_J^i} \right)^{1-\alpha}$. We then obtain that $\frac{\partial p_{x,J}^i}{\partial x_J^i} = -(1 - \alpha) \frac{p_{x,J}^i}{x_J^i}$. The first order conditions of (4) are $p_{x,J}^i + x_J^i \frac{\partial p_{x,J}^i}{\partial x_J^i} - 1 = 0$ for $J \in \{A, F\}$. As standard, we obtain constant price $p_{x,J}^i = 1/\alpha$ and $x_J^i = l_J^i L^i J^i \alpha^{\frac{2}{1-\alpha}} (p_J^i)^{\frac{1}{1-\alpha}}$. Using this in (2) and (4) gives (9) and (10). For wage, we use the above and (9) and note that consumers optimally allocate their labor for the sector that pays the highest wage.

A.2 Proof of Lemma 2

In autarky, both countries must be incompletely specialized, i.e., $w_A^i = w_F^i$. From (11), we then obtain that it must hold that $(p_A^i)^{\frac{1}{1-\alpha}} A^i = (p_F^i)^{\frac{1}{1-\alpha}} F$. Using (13) and the fact that $A^w = 1$ and A^c is given by (1) then gives (15) and (16). Using (16), (10) and labor market clearing $l_A^c + l_F^c = 1$, we find that if the country c does not invest in technology, then profits are $\pi^c(1, F) = (1 - \alpha) \alpha \alpha^{\frac{2\alpha}{1-\alpha}} F^{(1-\gamma)} \theta^{\frac{1}{1-\alpha}}$; and if it invests then $\pi^c(1, F) = (1 - \alpha) \alpha \alpha^{\frac{2\alpha}{1-\alpha}} F^{(1-\gamma)} \theta^{\frac{1}{1-\alpha}} \bar{A}^\gamma$. Condition (17) then follows from (5). We use (15), (16), (11), (10) in (8) to find the consumption (18) and (19).

A.3 Proof of Lemma 3

Because $l_A^c = 1$ and prices are given by (22), we obtain from (10) that if the country c does not invest in technology then profits are $\pi^c(1, F) = (1 - \alpha) \alpha \alpha^{\frac{2\alpha}{1-\alpha}} F^{(1-\gamma)} \theta^{\frac{1}{1-\alpha}}$ and if it invests then $\pi^c(\bar{A}, F) = (1 - \alpha) \alpha \alpha^{\frac{2\alpha}{1-\alpha}} F^{(1-\gamma)} \theta^{\frac{1}{1-\alpha}} \bar{A}$ and condition (23) follows from (5). Equation (24) follows then from (22), (11), (10) and (8). For import note that $\chi_F^c = 0$ and current account (21) implies that the imported quantity is $(Y_F^c - \chi_F^c) = Y_F^c = \frac{p_A}{p_F} (\chi_A^c - Y_A^c)$ and $p_F Y_F^c + p_A Y_A^c = p_A \chi_A^c$. From (12), we know that it must hold that $p_F Y_F^c + p_A Y_A^c = \frac{1}{1-\gamma} Y_F^c p_F$. Therefore, $p_F Y_F^c = (1 - \gamma) p_A \chi_A^c$. Using the (22) and (9), we obtain that imports are $(Y_F^c - \chi_F^c) = Y_F^c = (1 - \gamma) \frac{p_A}{p_F} \chi_A^c = (1 - \gamma) \alpha^{\frac{2\alpha}{1-\alpha}} \theta^{\frac{1}{1-\alpha}} F^{1-\alpha\gamma} \bar{A}$

A.4 Proof that the rest of the world is incompletely specialized.

Here we verify that the world remains incompletely specialized, and produces both A-good and F-good if the labor force in the rest of the world is large enough. Suppose that there is a finite number N countries that invest in developing a comparative in producing A good identical to country c is Section ??? and fully specialize in A-good, i.e., $l_A^c = 1$ and (9) it the follows that all these countries produce

$$\chi_A^c = \alpha^{\frac{2\alpha}{1-\alpha}} (p_A)^{\frac{\alpha}{1-\alpha}} \bar{A} \text{ and } \chi_F^c = 0. \quad (47)$$

The worldwide market clearing condition then implies that

$$Y_A^w + N \cdot Y_A^c = \chi_A^w + N \cdot \chi_A^c \text{ and } Y_F^w + N \cdot Y_F^c = \chi_F^w.$$

In the case of free trade, from (12) it holds that $p_A Y_A^i = \frac{\gamma}{1-\gamma} p_F Y_F^i$ for any i . Adding these up for all countries, it must hold that $p_A (Y_A^w + N \cdot Y_A^c) = \frac{\gamma}{1-\gamma} p_F (Y_F^w + N \cdot Y_F^c)$ and using the worldwide market clearing condition, $\frac{p_A}{p_F} = \frac{\gamma}{1-\gamma} \frac{\chi_F^w}{\chi_A^w + N \cdot \chi_A^c}$. From (9) and (47), we then obtain

that

$$\begin{aligned}\frac{p_A}{p_F} &= \frac{\gamma}{1 - \gamma} \frac{\alpha^{\frac{2\alpha}{1-\alpha}} L^w (p_F)^{\frac{\alpha}{1-\alpha}} l_F^w F}{\alpha^{\frac{2\alpha}{1-\alpha}} L^w (p_A)^{\frac{\alpha}{1-\alpha}} l_A^w + N \cdot \alpha^{\frac{2\alpha}{1-\alpha}} (p_A)^{\frac{\alpha}{1-\alpha}} \bar{A}} \\ \left(\frac{p_A}{p_F}\right)^{\frac{1}{1-\alpha}} &= \frac{\gamma}{1 - \gamma} \frac{L^w l_F^w F}{L^w l_A^w + N \bar{A}}\end{aligned}$$

Because from (11), incomplete specialization in the rest of the world must imply equal wages across sectors, we obtain that $w_A^w = w_F^w \iff (p_A)^{\frac{1}{1-\alpha}} = (p_F)^{\frac{1}{1-\alpha}} F$. Hence $\left(\frac{p_A}{p_F}\right)^{\frac{1}{1-\alpha}} = F = \frac{\gamma}{1-\gamma} \frac{L^w l_F^w F}{L^w l_A^w + N \bar{A}} \iff (1 - \gamma) (L^w l_A^w + N \bar{A}) = \gamma L^w l_F^w$. As $l_F^w = 1 - l_A^w$, this implies that $l_A^w = \gamma - \frac{(1-\gamma)N\bar{A}}{L^w}$. Clearly $l_A^w < 1$ and $l_A^w \geq 0$ if $L^w \geq \frac{(1-\gamma)}{\gamma} N \bar{A}$ and large enough labor force in the rest of the world guarantees incomplete specialization in the rest of the world. Also it is worth noting that we considered N countries specialized in A in the case of free trade. In the presence of any trade restrictions, even less restrictive condition for the rest of the world's incomplete specialization is needed.

A.5 Proof of Proposition 7

It must hold that $\tilde{\tau}_A^* \in [0, 1]$. Using (20), (??), and $\tilde{\pi}_2^u = \alpha \Gamma \bar{A} (1 - \tilde{\tau}_A^*)^{\frac{1}{1-\alpha}}$ in (39), the first order condition can be written as

$$LHS(\tilde{\tau}_A^*) \equiv 1 - \tilde{\tau}_A^* = \left(\frac{\alpha - \alpha\gamma}{1 - \alpha\gamma}\right)^{1-\gamma} \left(1 + \frac{1 - \alpha}{1 - \gamma} (1 - \tilde{\tau}_A^*)\right)^{1-\gamma} \equiv RHS(\tilde{\tau}_A^*) \quad (48)$$

The slopes of $RHS(\tilde{\tau}_A^*)$ and $LHS(\tilde{\tau}_A^*)$ as both negative as $\frac{\partial LHS(\tilde{\tau}_A^*)}{\partial \tilde{\tau}_A^*} = -1 < 1$ and $\frac{\partial RHS(\tilde{\tau}_A^*)}{\partial \tilde{\tau}_A^*} = -\left(\frac{\alpha - \alpha\gamma}{1 - \alpha\gamma}\right)^{1-\gamma} (1 - \alpha) \left(1 + \frac{1 - \alpha}{1 - \gamma} (1 - \tilde{\tau}_A^*)\right)^{-\gamma} < 0$. A sufficient condition for a unique solution in such a case is that $\lim_{\tilde{\tau}_A^* \rightarrow 0} LHS(\tilde{\tau}_A^*) > \lim_{\tilde{\tau}_A^* \rightarrow 0} RHS(\tilde{\tau}_A^*)$ and $\lim_{\tilde{\tau}_A^* \rightarrow 1} LHS(\tilde{\tau}_A^*) < \lim_{\tilde{\tau}_A^* \rightarrow 1} RHS(\tilde{\tau}_A^*)$. This can be confirmed to hold. First, $\lim_{\tilde{\tau}_A^* \rightarrow 0} LHS(\tilde{\tau}_A^*) = 1$ and $\lim_{\tilde{\tau}_A^* \rightarrow 0} RHS(\tilde{\tau}_A^*) = \left(\frac{\alpha - \alpha\gamma}{1 - \alpha\gamma}\right)^{1-\gamma} \left(1 + \frac{1 - \alpha}{1 - \gamma}\right)^{1-\gamma} = \left(\frac{\alpha(2 - \gamma - \alpha)}{1 - \alpha\gamma}\right)^{1-\gamma} < 1$, because $2\alpha - \gamma\alpha - \alpha^2 < 1 - \alpha\gamma \iff 0 < (1 - \alpha)^2$, thus $\lim_{\tilde{\tau}_A^* \rightarrow 0} LHS(\tilde{\tau}_A^*) > \lim_{\tilde{\tau}_A^* \rightarrow 0} RHS(\tilde{\tau}_A^*)$. Second, $\lim_{\tilde{\tau}_A^* \rightarrow 1} LHS(\tilde{\tau}_A^*) = 0$

and $\lim_{\tilde{\tau}_A^* \rightarrow 1} RHS(\tilde{\tau}_A^*) = \left(\frac{\alpha - \alpha\gamma}{1 - \alpha\gamma}\right)^{1-\gamma} > 0$. Therefore, there is a unique solution.

If firms in Upstream are owned by the local investors there, then from (36) $LHS(\tau_A^*) = 1 - \tau_A^*$ and $RHS(\tau_A^*) = \left(\frac{\alpha - \alpha\gamma}{1 - \alpha\gamma}\right)^{1-\gamma}$. Given that $\lim_{\tilde{\tau}_A^* \rightarrow 1} RHS(\tau_A^*) = RHS(\tilde{\tau}_A^*)$, then $\tau_A^* > \tilde{\tau}_A^*$ if $\frac{\partial LHS(\tilde{\tau}_A^*)}{\partial \tilde{\tau}_A^*} < \frac{\partial LHS(\tau_A^*)}{\partial \tau_A^*}$, which holds because $\frac{\partial LHS(\tilde{\tau}_A^*)}{\partial \tilde{\tau}_A^*} < 0$ and $\frac{\partial LHS(\tau_A^*)}{\partial \tau_A^*} = 0$. This proves the proposition.

A.6 Proof of Lemma 8

The investment in technology in Upstream pays off if $\pi_1^u + \tilde{P}_\pi^u > I$. Using then $\pi_1^u = \alpha\Gamma$, $\tilde{P}_\pi^u = \beta\tilde{\pi}_2^u + (1 - \beta)\pi_2^u = \beta\alpha\Gamma\bar{A}(1 - \tilde{\tau}_A^*)^{\frac{1}{1-\alpha}} + (1 - \beta)\alpha\Gamma\bar{A}(1 - \tau_A^*)^{\frac{1}{1-\alpha}}$, and that in the case of ownership by local investors in Upstream, the investment pays off if $\pi_1^u + \pi_2^u = \alpha\Gamma + \alpha\Gamma\bar{A}(1 - \tau_A^*)^{\frac{1}{1-\alpha}} = I^v > I$, proves that (40) holds. Using (11), $\tilde{P}_\pi^u$ and (??), consumption in Upstream with Downstream investors is $\tilde{C}_v^u = \Gamma + \Gamma\bar{A}(1 - \tilde{\tau}_A^*)^{\frac{1}{1-\alpha}} + \alpha\Gamma + \beta\alpha\Gamma\bar{A}(1 - \tilde{\tau}_A^*)^{\frac{1}{1-\alpha}} + (1 - \beta)\alpha\Gamma\bar{A}(1 - \tau_A^*)^{\frac{1}{1-\alpha}} - I$. With local investors, it is $C_v^u = \Gamma + \Gamma\bar{A}(1 - \tau_A^*)^{\frac{1}{1-\alpha}} + \alpha\Gamma + \alpha\Gamma\bar{A}(1 - \tau_A^*)^{\frac{1}{1-\alpha}} - I$. Combining these, we obtain (41). From Lemma 7, it is straightforward that $(1 - \tilde{\tau}_A^*)^{\frac{1}{1-\alpha}} - (1 - \tau_A^*)^{\frac{1}{1-\alpha}} > 0$.

A.7 Proof of Lemma 9

Given that the takeover investments do not affect the production decisions in Downstream, $\tilde{C}_v^d \geq C_v^d$ if $\tilde{\pi}_2^u - \tilde{P}_\pi^u + \tilde{T}_v^{d*} \geq T_v^{d*}$, where $\tilde{T}_v^{d*}$ is the fee revenue (35) in the case of $\tau_A = \tilde{\tau}_A^*$ and T_v^{d*} is the fee revenue in the case of $\tau_A = \tau_A^*$. Given that $\tilde{\pi}_2^u - \tilde{P}_\pi^u = (1 - \beta)(\tilde{\pi}_2^u - \pi_2^u)$, Downstream benefits from the ownership of firms in Upstream if $\beta \leq \bar{\beta} = 1 - \frac{T_v^{d*} - \tilde{T}_v^{d*}}{\tilde{\pi}_2^u - \pi_2^u}$. As τ_A^* maximizes the fee revenue, it is clear that $T_v^{d*} > \tilde{T}_v^{d*}$. Therefore, it must hold that $\bar{\beta} < 1$. Using (35), $\tilde{\pi}_2^u$, π_2^u and the expressions for the optimal fees from (36) and (48), it is clear that $\bar{\beta}(\alpha, \gamma)$ depends only on the parameters α and γ . The threshold $\bar{\beta}(\alpha, \gamma)$, for any values of $\alpha \in (0, 1)$ and $\gamma \in (0, 1)$ is presented on Figure 2.

B Data Sources

The main data are from Subramanian and Wei (2007) and are downloadable at http://www.nber.org/~wei/data/subramanian&wei2003/sw_aggregate.zip. The dependent variable is value of bilateral imports of 152 countries measured at 5 year intervals between 1950 and 2000, Subramanian and Wei collect these from the IMF's direction of trade statistics.. The explanatory variables build on Rose (2004). This is the data source for the number of islands in trading relation, as well as dummies capturing common language, common colonizer, former colonial relation, current colonial relation, currency union membership, free trade agreement, if imports to industrial country i from country j are covered by the generalized system of preferences and one/both in WTO. Imports are in US 1982-83 dollars. In some specifications we use foreign direct investment liabilities as an explanatory variable, these are from Lane and Milesi-Ferretti (2007). The main difference from Subramanian and Wei (2007) is distance. As our measure of main cities we use data from CEPII (Mayer and Zignago (2006)) which is also our source of the great circle distance measure between these main cities. These are downloadable from <http://www.cepii.fr/anglaisgraph/bdd/distances.htm>. Distance to the closest port is from www.findaport.com and distances between ports are from www.portworld.com. The set of countries in the CEPII study is not the same as in Subramanian and Wei. The list of countries is the following

Not Landlocked:

Albania, Algeria, Angola, Argentina, Australia, Bahamas, The Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bermuda, Brazil, Bulgaria, Cambodia, Cameroon, Canada, Chile, China,P.R.: Mainland, China,P.R.: Hong Kong, Colombia, Dem. Rep. of Congo, Republic of Congo, Costa Rica, Croatia, Cyprus, Côte d'Ivoire, Denmark, Djibouti, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Estonia, Fiji, Finland, France, Gabon, The Gambia, Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Iceland, India, Indonesia, I.R. of Iran, Iraq, Ire-

land, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Kiribati, Korea, Kuwait, Latvia, Liberia, Libya, Lithuania, Madagascar, Malaysia, Malta, Mauritania, Mauritius, Mexico, Moldova, Morocco, Mozambique, Myanmar, Netherlands, New Zealand, Nicaragua, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Peru, Philippines, Poland, Portugal, Qatar, Russia, Samoa, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Singapore, Slovenia, Somalia, South Africa, Spain, Sri Lanka, St. Kitts and Nevis, Sudan, Suriname, Sweden, Syrian Arab Republic, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Rep. Bol. Venezuela, Vietnam, Republic of Yemen.

Landlocked:

Armenia, Austria, Azerbaijan, Bolivia, Burkina Faso, Burundi, Central African Rep., Chad, Czech Republic, Ethiopia, Hungary, Kazakhstan, Kyrgyz Republic, Lao People's Dem. Rep, FYR Macedonia, Malawi, Mali, Mongolia, Nepal, Niger, Paraguay, Rwanda, Slovak Republic, Switzerland, Tajikistan, Turkmenistan, Uganda, Uzbekistan, Zambia, Zimbabwe.

Countries in Subramanian & Wei (2007) but not in our main regressions:

Antigua and Barbuda, Bhutan, Botswana, Cape Verde, Comoros, Dominica, Grenada, Lesotho, Luxembourg, Maldives, Namibia, Réunion, Solomon Islands, St. Lucia, St. Vincent & Grens., Swaziland, São Tomé & Príncipe, Tonga, Vanuatu, SFR Yugoslavia.

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