HOLDUP AND INTERNATIONAL TRADE*

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Abstract

Concerns about the division of gains from trade can limit the realization of such gains. These concerns are particularly stark for countries whose trade must pass a transit country to reach world markets. We develop a general equilibrium model with imperfect competition where a potential holdup problem makes such countries poorer and less likely to invest in technology to exploit 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. Having trade via a transit country reduces bilateral trade by more than 50 percent.

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 more than their fair share of surplus are central to many policy debates. Examples of such fears come from debates about foreign sovereign wealth funds as owners, the role of multinationals in the least developed countries or dependency on imports of food and energy. We know that factors that affect the splitting of the surplus

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 (2006) for an analysis of market power in international shipping).

While our motivation is broad, the setup matches the trade relations of landlocked countries, which are interesting in their own right.[3] Outside Europe, landlocked countries are typically poor - 12 out of 26 countries that are categorized as having the lowest development according to the 2008 UN Human Development Index are landlocked (this represents more than half of the landlocked countries outside Europe - see Collier (2007), Faye, McArthur, Sachs and Snow (2004) for analysis).[4] From before 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 Marteua (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*".

Such rent activities suggest 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 the new technology, on the possibility to write binding contracts and the nature of fees (fixed or variable) that the transit country charges of the landlocked country. 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

[3]While economically marginalized outside Europe, they are home to a sizeable population: landlocked countries such as Burkina Faso, Chad or Mali each have a population of more than 10 million and landlocked Ethiopia a population of 77 million (Source: World Development Indicators, 2006.) In addition population growth is rapid in these countries, making it particularly important to generate technological progress to avoid a Malthusian crisis (see André and Platteau (1998) for a Malthusian analysis of the genocide in Rwanda, another landlocked African country).

[4]GDP per capita in landlocked countries outside Europe was on average 2493 usd and in coastal 8706 usd (data from 2006 from World Development Indicators in 2005 usd using ppp exchange rates). The difference is statistically significant (t-stat 2.55).

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. The reason is that a monopolistic distortion gives too weak investment incentives to the Upstream technology producer: Opening up to world markets and financing transit fees with taxes can act as a welfare enhancing investment subsidy. However, if trade agreements are renegotiable and investment costs are sufficiently high, Upstream is better off by committing to stay in autarky.

We extend the model to address the effect of foreign ownership of firms in Upstream. Foreign ownership is in some quarters seen just as foreign appropriation of the surplus from trade. In contrast, 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.

We proceed to examine the implications in a gravity model of bilateral imports using data for 1950-2000 (the data set largely builds on Subramanian and Wei (2007)). 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.

A key prediction of the model is that landlocked countries are less likely to export products that require a sunk cost of investment. In Appendix A we use data from 2000 to compare exports across coastal and landlocked countries. This confirms 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. Another frequently used classification of goods is Rauch's (1999) division into differentiated, exchange traded and reference priced products. The results on the duration of imports for these categories by Besedes and Prusa (2006) points to that the sunk cost of entering an export market are greater for differentiated products. Consistent with our model, the share of differentiated products in exports is lower for landlocked countries outside Europe.

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 it has not been modeled previously.[5] 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.[6] 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)). Our model differs in several ways from that of McLaren, in particular we study imperfect competition, have three regions and allow for foreign ownership of firms. Explicitly modelling the investment decision, rather than having firms choose industry as in McLaren (1997), also allows us to examine the interplay between investments, monopoly distortions and transit fees.

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. These works do not explore the potential for holdup at the country level that is our focus. Somewhat related is also Martin, Meyer and Thoenig (2008), who theoretically and empirically study how the costs of war between two countries depend on the extent of their bilateral trade dependence. 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

[5] A 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 Prébish-Singer notion that deteriorating terms of trade for primary products make developing countries loose out on trade (see for instance Prébish 1959) and partly on Marxist analysis (see for instance Gunder Frank (1967)). As will become apparent, our framework is very different.

[6] McLaren (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.

problem - anticipating the high fees the merchant may never set out from his home.[7] 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.

In Section 2.1 we set up the model and in Section 2.2 we solve for the autarky and free trade benchmarks. Then in Section 2.3 we turn to our main analysis - considering trade negotiations under fixed and variable fees to the transit country and identifying the conditions under which the Upstream benefits from opening up to trade. In section 2.4 we relax the assumption that all firms are owned by local residents. Section 3 then outlines main predictions from our model and examines trade patterns in a gravity framework. We conclude in Section 4.

2 The model

2.1 The setup

Consider a world with two time periods $t \in \{1, 2\}$ and three countries: Upstream, Downstream and the rest of the world, indexed with $i \in \{u, d, w\}$. All trade between Upstream and the rest of the world must go through Downstream, while the rest of the world and Downstream can trade directly. This gives Downstream an opportunity to charge fees from Upstream. Apart from their location, Upstream and Downstream are identical in period one. To highlight the main mechanism, we abstract from the incentives to trade between Upstream and Downstream. Consumers only consume a composite final good which is produced using specialized goods as inputs. Allowing transfers and investments to be made in a straightforward manner in the units of the final good simplifies the analysis. The production of one of the specialized inputs can be made more efficient by technology investments. The introduction of a separate technology sector also simplifies the analysis by allowing us to solve for the equilibrium trade and optimal technology investment decisions separately.

2.1.1 Consumers

Consumers in country i consume only in period two[8] and their utility equals expected consumption in period two. Each consumer in country i is endowed with one unit of labor each

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

[8] This assumption is to abstract from considerering the impact of trade negotiations on the world interest rates and to consider the pure effect of openess to foreign capital flows as an argument in trade negotiations.

period and receives wage w_t^i in period t. The number of consumers force in Upstream and Downstream is the same and normalized to one, $L^u = L^d = 1$. The number of consumers in the rest of the world is substantially higher $L^w >> 2$. In addition to wage income, consumers in country i own monopolistic firms in their country.[9] These firms produce profits π_t^i in period t and can invest in technology, I^i, in period one. The choice to invest is denoted with an indicator function $\tilde{1}^i = 1$ if investment is undertaken and $\tilde{1}^i = 0$ otherwise.

As an outcome of trade negotiations, consumers in country i can receive transfers or pay taxes to the government. These net transfers are denoted with T^i. Consumers only consume a composite final good, the price of which we normalize to 1. The average per capita consumption in county i is then

$$\frac{C^i}{L^i} = w_1^i + w_2^i + \frac{\pi_1^i + \pi_2^i + T^i - I^i \tilde{1}^i}{L^i}. \tag{1}$$

2.1.2 Final good production

The consumption (final) good is produced with a Cobb-Douglas technology[10]

$$Y_t^i = \left(Y_{A,t}^i\right)^\gamma \left(Y_{F,t}^i\right)^{1-\gamma}, \tag{2}$$

where $Y_{F,t}^i$ and $Y_{A,t}^i$ denote the quantity of specialized goods A and F used in each country and $\gamma \in (0,1)$.

The final goods' sector is perfectly competitive and chooses inputs to maximize profits

$$\max_{Y_{F,t}^i, Y_{A,t}^i} pY_t^i - p_{F,t} Y_{F,t}^i + p_{A,t} Y_{A,t}^i \text{ st. } (2), \tag{3}$$

where $p_{F,t}$ and $p_{A,t}$ are the prices of good A and F respectively and the price of the final good is normalized to one, i.e. $p = 1$. As the final good is the same in all countries, the sole motivation for trading this good is as a means of payment.

2.1.3 Specialized goods production and trade

The specialized goods A and F are produced by a competitive specialized goods sector in each country. Country i produces $\chi_{A,t}^i$ and $\chi_{F,t}^i$ units of the specialized goods A and F

[9] In Section 2.4 we relax this assumption and consider ownership of firms in another country.

[10] An equivalent setup would be to consider consumers that have similar Cobb-Douglas preferences over two consumption goods. The results are also robust to considering a general constant elasticity of substitution technology and are available upon request.

respectively in period t. The specialized goods have Cobb-Douglas production function

$$\chi^i_{A,t} = \left(l^i_{A,t} L^i A^i_t\right)^{1-\alpha} {x^i_{A,t}}^{\alpha} \text{ and } \chi^i_{F,t} = \left(l^i_{F,t} L^i F^i_t\right)^{1-\alpha} {x^i_{F,t}}^{\alpha}, \tag{4}$$

where $l^i_{A,t}$ and $l^i_{F,t}$ is the share of labor force, A^i_t and F^i_t is the quality of technology and $x^i_{A,t}$ and $x^i_{F,t}$ is the capital invested in the A and F sectors respectively. Capital and labor are not mobile across countries.

Specialized goods producers take the price of specialized goods $p_{j,t}$ as given and

$$\max_{l^i_{j,t}, x^i_{j,t}} p_{j,t}\chi^i_{j,t} - w^i_{j,t} l^i_{j,t} L^i - p^i_{x,j,t} x^i_{j,t} \text{ st. (4)} \tag{5}$$

for every $i \in \{u, d, w\}$ and $j \in \{A, F\}$. The price of capital goods is denoted by $p^i_{x,j,t}$ for $j \in \{A, F\}$. Assume that capital fully depreciates in one period. There are no transportation costs and world production equals usage of specialized goods

$$\chi^w_{j,t} + \chi^u_{j,t} + \chi^d_{j,t} = Y^w_{j,t} + Y^u_{j,t} + Y^d_{j,t}. \tag{6}$$

2.1.4 Technology sector

The capital, $x^i_{j,t}$, is produced by a monopolistic technology firm in each country. Both capital goods are produced by the same monopoly (called "technology producer"), who uses one unit of the final good to produce one unit of capital good in each sector and

$$\max_{x^i_{A,t}, x^i_{F,t}} \pi^i_t = \sum_{j=A,F} p^i_{x,j,t} x^i_{j,t} - x^i_{j,t} \text{ st. } \frac{\partial p^i_{x,j,t}}{\partial x^i_{j,t}}. \tag{7}$$

The initial quality of the technology is the same in all countries. The initial productivity in the A-sector is normalized to one, i.e. $A^i_1 = 1$ for every i. Technology in the F-sector cannot be improved, i.e. $F^i_1 = F^i_2 = F$.

In both Upstream and Downstream, the quality of capital goods in sector A can be improved. When the monopolist in country $i \in \{u, d\}$ invests in I units of final good in period 1, the quality of technology in period 2 is $\bar{A} > 1$. Investment in technology pays off if

$$\pi^i_2(\bar{A}, F) - \pi^i_2(1, F) \geq I. \tag{8}$$

We assume that there is no such opportunity in the rest of the world, i.e. $A^w_2 = 1$. This allows Upstream and Downstream to develop a comparative advantage in producing the A-good and gives them motivation to trade with the rest of the world in period 2.

2.1.5 Government and trade negotiations

The objectives of governments are assumed to be maximize (1), the welfare of local consumers. While we abstract from transportation costs, the location of Upstream gives Downstream an opportunity to charge fees to allow passage of upstream goods to the rest of the world.. The governments of Upstream and Downstream negotiate in period 1 about the size of these fees. In the basic model, we consider the following possibilities: fixed fees with no commitment, fixed fees with commitment and variable fees that depend on the volume of goods passing through Downstream.

The potential income from these fees is distributed as lump sum transfers, $T^d > 0$, (in terms of the final good) to consumers in Downstream. Such fixed fees are paid by the government in Upstream which it finances by lump sum taxes, $T^u < 0$.

2.2 Solution of the model and benchmarks

2.2.1 Production decisions

Before we analyze the equilibrium in autarky and in trade, it is useful to solve the problem of producers in different sectors. The final goods producers' problem (3) gives an inverse relationship between relative prices and demand of goods A and F

$$\frac{p^i_{A,t}}{p^i_{F,t}} = \frac{\gamma}{1-\gamma}\frac{Y^i_{F,t}}{Y^i_{A,t}}. \tag{9}$$

Using this, the fact that perfect competition implies zero profits in the final goods' sector (3) and the production function (2), we can derive the price index

$$p = 1 = \frac{\left(p^i_{A,t}\right)^{\gamma}\left(p^i_{F,t}\right)^{1-\gamma}}{\theta}, \text{ where } \theta \equiv (\gamma)^{\gamma}(1-\gamma)^{1-\gamma}. \tag{10}$$

The first order conditions of the specialized producers' problem gives wages

$$w^i_{A,t} = (1-\alpha)\, p^i_{A,t}\frac{\chi^i_{A,t}}{l^i_{A,t}L^i} \text{ and } w^i_{F,t} = (1-\alpha)\, p^i_{F,t}\frac{\chi^i_{F,t}}{l^i_{F,t}L^i} \tag{11}$$

and demand for capital in sector j that is linear in the quality of the respective technology

$$x^i_{A,t} = \alpha^{\frac{1}{1-\alpha}}\left(\frac{p^i_{A,t}}{p^i_{x,A,t}}\right)^{\frac{1}{1-\alpha}} l^i_{A,t}L^iA_t \text{ and } x^i_{F,t} = \alpha^{\frac{1}{1-\alpha}}\left(\frac{p^i_{F,t}}{p^i_{x,F,t}}\right)^{\frac{1}{1-\alpha}} l^i_{F,t}L^iF.$$

From the capital goods sector maximization (7) we obtain the price of capital goods

$p^i_{x,A,t} = \frac{1}{\alpha}$ and $p^i_{x,F,t} = \frac{1}{\alpha}$. Using these in (4), the output of specialized goods is

$$\chi^i_{A,t} = \alpha^{\frac{2\alpha}{1-\alpha}} \left(p^i_{A,t}\right)^{\frac{\alpha}{1-\alpha}} l^i_{A,t} L^i A^i_t \text{ and } \chi^i_{F,t} = \alpha^{\frac{2\alpha}{1-\alpha}} \left(p^i_{F,t}\right)^{\frac{\alpha}{1-\alpha}} l^i_{F,t} L^i F. \tag{12}$$

The profit of the technology producer,

$$\pi^i_t = \alpha (1-\alpha) \alpha^{\frac{2\alpha}{1-\alpha}} \left[\left(p^i_{A,t}\right)^{\frac{1}{1-\alpha}} l^i_{A,t} A_t + \left(p^i_{F,t}\right)^{\frac{1}{1-\alpha}} l^i_{F,t} F\right] L^i, \tag{13}$$

is increasing in the quality and prices of A and F. From (11) and (12), also the wages,

$$w^i_{A,t} = (1-\alpha) \alpha^{\frac{2\alpha}{1-\alpha}} \left(p^i_{A,t}\right)^{\frac{1}{1-\alpha}} A^i_t \text{ and } w^i_{F,t} = (1-\alpha) \alpha^{\frac{2\alpha}{1-\alpha}} \left(p^i_{F,t}\right)^{\frac{1}{1-\alpha}} F \tag{14}$$

are increasing of quality and prices in their respective sectors.

2.2.2 autarky and free trade

In autarky, both specilized goods are produced in all countries. Equating the wages across sectors (11) and using the price index (10) implies that autarky prices are given by

$$\hat{p}^i_{A,t} = \theta \left(F/\hat{A}^i_t\right)^{(1-\gamma)(1-\alpha)} \text{ and } \hat{p}^i_{F,t} = \theta \left(F/\hat{A}^i_t\right)^{-\gamma(1-\alpha)}. \tag{15}$$

Lemma 1 *In autarky, Upstream and Downstream invest in technology if the cost of technology investments*

$$I \leq \hat{I} = \alpha\Gamma \left(\bar{A}^\gamma - 1\right). \tag{16}$$

Consumption per capita in period 1 in all countries is $\bar{C} \equiv 2\Gamma(1+\alpha)$*. In period 2, consumption in the rest of the world is* $\bar{C}$ *and in the Upstream and the Downstream is*

$$\begin{aligned} \hat{C}^u\left(\bar{A}\right) = \hat{C}^d\left(\bar{A}\right) &= \bar{C} + \Gamma\left(\bar{A}^\gamma - 1\right) + \hat{I} - I \text{ if } I \leq \hat{I} \\ \hat{C}^u(1) = \hat{C}^d(1) &= \bar{C} = 2\Gamma(1+\alpha) \text{ if } I > \hat{I}, \end{aligned} \tag{17}$$

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

Proof. See Appendix B.1. ∎

If investment in technology pays off, i.e. $\hat{I} \geq I$, consumption in Upstream and Downstream is higher than in the rest of the world. As in 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. $\hat{C}^u\left(\bar{A}\right) = \hat{C}^d\left(\bar{A}\right) > \bar{C}$ even if $\hat{I} = I$. This is because investments in technology

lead to higher wages that are not reflected in the profits of technology producers.

If there is free trade, there are incentives to trade only in period 2, if Upstream and Downstream invest in technology, $A_2^d = A_2^u = \bar{A}$. As the rest of the world is assumed to be substantially larger than Upstream and Downstream together[11], Upstream and Downstream countries fully specialize in production of the A-good, i.e. $l_{A,2}^u = l_{A,2}^d = 1$. The rest of the world incompletely specializes in production of the F-good and the wages there have to be equalized across sectors, $w_{A,2}^w = w_{F,2}^w$. From the price index (10) and wages (14), it is clear that the free-trade prices are the same as in autarky in the rest of the world, i.e.

$$p_{A,2} = \hat{p}_{F,t}^w = \theta F^{(1-\gamma)(1-\alpha)} \text{ and } p_{F,t} = \hat{p}_{F,t}^w = \theta F^{-\gamma(1-\alpha)}. \tag{18}$$

Lemma 2 *In the case of free trade, Upstream and Downstream invest in technology if the cost of technology investments*

$$I = I^T \leq \alpha\Gamma\left(\bar{A} - 1\right). \tag{19}$$

Consumption in period 2 in Upstream and Downstream is

$$C_{FT}^u\left(\bar{A}\right) = C_{FT}^d\left(\bar{A}\right) = \bar{C} + \Gamma\left(\bar{A} - 1\right) + I^T - I \text{ if } I < I^T \tag{20}$$

and $\bar{C}$ otherwise and in period 1.[12]

Proof. See Appendix B.2. ■

As $\bar{A} > \bar{A}^\gamma$ the threshold level that justifies technology investments is higher than in autarky, i.e. $I^T > \hat{I}$ (see (16)). In the interval $\left[\hat{I}, I^T\right]$ technology investments occur only because of a decision to be open to trade. Higher equilibrium prices of the A-good in the case of free trade create further incentives for investments in that sector. As a result, also the consumption per capita in Upstream and Downstream is higher, because $\bar{A} > \bar{A}^\gamma$ and $I^T > \hat{I}$ (see(17)). Higher consumption compared to autarky is driven by both higher returns for technology producers and by higher wages.

[11] To be specific, it must hold that $L^w \geq 2\frac{1-\gamma}{\gamma}\bar{A}$. This condition guarantees that the A-good producers' labor demand is non-negative.

[12] Despite the changes in production of specialized goods in the rest of the world, the wages and profit there remain unchanged compared to autarky. Therefore, also the consumption in the rest of the world remains the same as in autarky, $\bar{C}$ (see (17)) This is because incomplete specialization implies that prices in the rest of the world are the same as in autarky and the changes in the share of labor employed in specialized goods sectors fully accommodate the changes in the production of specialized goods.

2.3 Trade negotiations

The previous section showed that the possibility to innovate in the A-sector gives both Upstream and Downstream countries an opportunity to gain from free trade. This section assumes that the required technology investments always pay off when trade is free, i.e. $I < I^T$ (see equation (19)).We first consider trade negotiations about fixed fees before turning to the case of variable fees.

2.3.1 Fixed fees: no commitment

Suppose that Downstream cannot commit not to renegotiate the fees in period 2. The technology investment decision of agents in Upstream has then already been made when trade negotiations start. This captures that developing a comparative advantage through technology investments requires time and can make Upstream vulnerable to renegotiations.

Since the Upstream government finances the fee via taxes the fees do not alter the decisions of the producers and the wages and profits in all countries are the same as in the case of free trade. However, Upstream can always revert to autarky in period 2, in which case consumption is the same as in autarky $\hat{C}^u\left(\bar{A}\right)$ given that the investments pay off for the technology producers. The maximum fee, $T^u_{f\_nc}$, that Upstream is willing to pay in period 2 must satisfy

$$C^u\left(\bar{A}\right) - T^u_{f\_nc} \geq \hat{C}^u\left(\bar{A}\right). \tag{21}$$

The location of Downstream gives it all the bargaining power in trade negotiations. As consumption in Downstream is increasing in the fees it charges, the government of Downstream solves

$$\max T^d_{f\_nc} = T^u_{f\_nc} \text{ s.t. } (21) \tag{22}$$

Given the assumption that the rest of the world is sufficiently big, the equilibrium world prices do not change if Downstream reverts to autarky.

Lemma 3 *In the case of fixed fees with no commitment, the equilibrium fees are*

$$T^u_{f\_nc} = T^d_{f\_nc} = \Gamma\left(\bar{A} - \bar{A}^\gamma\right) + I^T - \hat{I} > 0 \tag{23}$$

and the consumption in Upstream and Downstream is

$$C^u_{f\_nc} = \bar{C} + \Gamma\left(\bar{A}^\gamma - 1\right) + \hat{I} - I \tag{24}$$
$$C^d_{f\_nc} = \bar{C} + \Gamma\left(2\bar{A} - \bar{A}^\gamma - 1\right) + \left(I^T - I\right) + \left(I^T - \hat{I}\right).$$

Proof. Given that Downstream has all bargaining power, (22) implies that (21) holds with equality. Using (17) and (20) in (21) and (1) proves the lemma. ■

From (20) and (24) consumption in Downstream is higher than in free trade and Upstream is lower than in free trade. Furthermore, consumption in Upstream can be lower than in the case where the Upstream stays in autarky. This can occur when investment costs are such that they are undertaken when there is trade but would not be undertaken if Upstream had committed to stay in autarky, i.e. $\hat{I} < I < I^T$. This leads to the following Corollary of Lemma 1.

Corollary 4 *Consumers in Upstream are worse off when trading compared to autarky if*

$$\hat{I}_{f\_nc} < I < I^T, \text{ where } \hat{I}_{f\_nc} = \hat{I} + \Gamma\left(\bar{A}^{\gamma} - 1\right) \tag{25}$$

Proof. If $\hat{I} < I < I^T$ technology producers in Upstream would not invest in improving the technology in the A-sector. This implies that the autarky consumption is $\bar{C}$, i.e. the same as in the rest of the world. Consumers in Upstream are worse off because of trade when $\bar{C} > C^u_{f\_nc}$. Using (24) this condition becomes $I > \hat{I} + \Gamma\left(\bar{A}^{\gamma} - 1\right)$ which proves the corollary. ■

Given that the fixed fees are not charged directly from technology producers, but from consumers[13], openness to trade induces higher investments in technology. A high investment cost ($I > \hat{I}_{f\_nc}$) leads to overinvestment in technology in Upstream. This occurs because at the time of trade renegotiations Upstream cannot reverse investments. Upstream would be better off if it would choose to remain in autarky to discourage such overinvestment.

At the same time, if cost of investments is not too high, consumers benefit in Upstream, as from (25), it holds that $\hat{I}_{f\_nc} > \hat{I}$. Because of its positive effect on wages, the social gain from better technology is higher than the gains to monopolistic firms. As trade increases the market for innovative products, it can compensate for the underinvestment we would see in autarky. The same outcome would occur if government would subsidize technology investments with lump-sum taxes from consumers (as in endogenous growth models, see e.g. Romer (1990)). If the cost of investments is not too high, openness to trade is a market based alternative to such subsidies[14]. Figure 1 summarizes the findings in this section.

[13] The argument holds in a more general setting. The crucial assumption here is that the fees are not fully reflected in the returns from technology investments. Section 2.3.3 that considers the variable fees addresses the opposite case where the returns are directly affected by trade agreements.

[14] Tinn and Vourvachaki (2009) emphasizes another market based mechanism that is an alternative to subsidies - the influence of a positive public signal/optimism in the equity market.

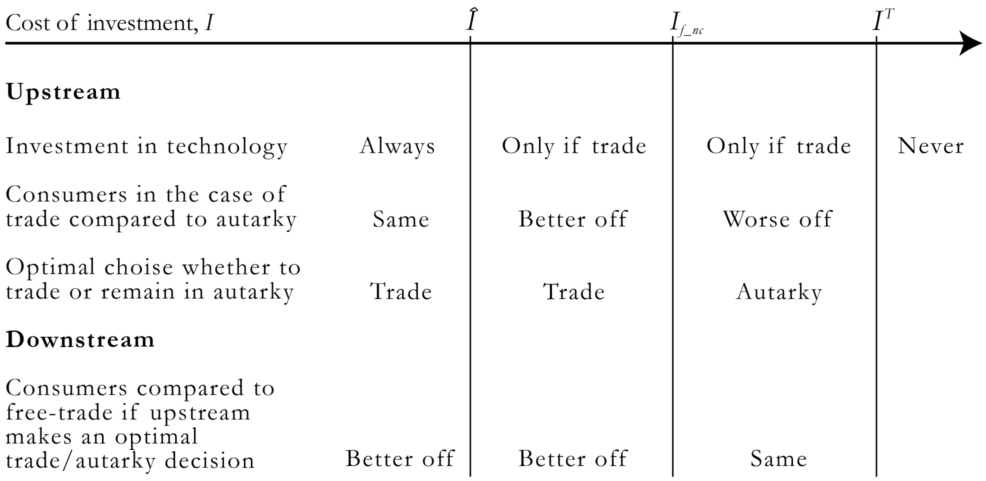

Figure 1: Possible outcomes, fixed fees

2.3.2 Fixed fees: commitment

We now consider the case where the fees are negotiated in period 1 and Downstream commits to these fees. In the previous section we showed that commitment problems are important only in the case where $\hat{I}_{f\_nc} < I < I^T$. In this range of investments, absent commitment, Upstream would choose not to trade and Downstream would not receive any fee income. In all other cases Upstream would not be worse off because of trade and the fees would be exactly the same as in the case of no commitment.

More formally, the optimal fee that Downstream charges must be low enough to avoid Upstream switching to autarky, and low enough to induce it to invest. The Downstream government solves

$$\begin{aligned} &\max T^d_{f\_c} = T^u_{f\_c} \\ &\text{s.t. } C^u\left(\bar{A}\right) - T^u_{f\_c} \geq \hat{C}^u\left(\bar{A}\right) \text{ and } C^u\left(\bar{A}\right) - T^u_{f\_c} \geq \bar{C}. \end{aligned} \tag{26}$$

Lemma 5 *If Downstream commits to fees before Upstream invests in technology, it charges fixed fees*

$$T^d_{f\_c} = T^u_{f\_c} = \begin{cases} T^d_{f\_nc} + \hat{I}_{f\_nc} - I \text{ if } \hat{I}_{f\_nc} < I < I^T \\ T^d_{f\_nc} \text{ if } I < \hat{I}_{f\_nc} \end{cases}, \tag{27}$$

where $T^d_{f\_nc}$ is given by (22). For $\hat{I}_{f\_nc} < I < I^T$ the consumption in Upstream and Down-

stream is

$$C^u_{f\_c} = \bar{C} + \Gamma\left(\bar{A}^\gamma - 1\right) + \hat{I} - \hat{I}_{f\_nc} \tag{28}$$
$$C^d_{f\_c} = C^d_{f\_nc} = \bar{C} + \Gamma\left(2\bar{A} - \bar{A}^\gamma - 1\right) + \left(I^T - \hat{I}_{f\_nc}\right) + \left(I^T - \hat{I}\right)$$

and for $I < \hat{I}_{f\_nc}$ it is $C^u_{f\_c} = C^u_{f\_nc}$ and $C^d_{f\_c} = C^d_{f\_nc}$.

Proof. Using (17), (20), (21) and (25) in (26), we see that the first condition $C^u\left(\bar{A}\right) - T^u_{f\_c} \geq \hat{C}^u\left(\bar{A}\right)$ is more restrictive if $I < \hat{I}_{f\_nc}$. In this case, the problem is the same as (22), $T^u_{f\_c} + T^u_{f\_nc}$ and Lemma 1 holds. The second condition, $C^u\left(\bar{A}\right) - T^u_{f\_c} \geq \bar{C}$, is more restrictive only if $\hat{I}_{f\_nc} < I < I^T$. In this case the Downstream government solves $\{\max T^d_{f\_c} = T^u_{f\_c} \text{ s.t } C^u\left(\bar{A}\right) - T^u_{f\_c} \geq \bar{C}\}$ and $T^u_{f\_c} = C^u\left(\bar{A}\right) - \bar{C}$. Using then (20) and (25) proves the lemma. ■

Lemma 3 and 5 emphasize that if $\hat{I}_{f\_nc} < I < I^T$, Downstream has incentives to commit to lower fees (i.e. $T^d_{f\_c} < T^d_{f\_nc}$), which then leads to gains for both countries compared to the situation where Upstream chooses to stay in autarky. However, this commitment is time inconsistent for Downstream who would benefit from renegotiating once Upstream has made its investment. This highlights that countries facing a holdup problem have lower incentives to invest in technology and to be open to trade, at least without binding trade agreements.[15]

2.3.3 Variable fees

As an alternative suppose that instead of a fixed fee Downstream charges a variable fee, such as a tariff, on the A and F goods that passes through its country. A variable fee will directly influence prices of goods in the Upstream and therefore directly affect the entrepreneur's decision to invest.

Let Downstream buy the F good from the rest of the world for a price $p_{F,2}$ and sell it to Upstream for a price $p^u_{F,2} = p_{F,2}\left(1 + \tau_F\right)$. Similarly, it buys the A-good from Upstream for a price $p^u_{A,2} = p_{A,2}\left(1 - \tau_A\right)$ and sells it to the rest of the world for a price $p_{A,2}$.

World prices are determined by the productivity in the rest of the world that is incompletely specialized. In particular, equating wages there, $w^w_{A,2} = w^w_{F,2}$ gives the same world prices as in free trade and (18) holds. It is easy to show that similar to free trade, the only variable that adjusts in the rest of the world is the share of labor employed in the A-sector

[15] In a repeated game, reputation costs could make the holdup problem less severe. The upstream country could threaten not to trade in the future, which gives dowstream country incentives not to renegotiate the fees. However, such a commitment would not be time consistent for the upstream country. Even if the downstream country renegotiates, it is ex-post optimal for the upstream country to trade if fees are not too high. In this case, bygones are bygones and a dynamic setting would be the same as a sequence of one-shot games analysed.

leaving $Y^w_{A,2}$, $Y^w_{F,2}$, Y^w_2 and C^w unchanged. Given the same prices, full specialization in the A-good in Downstream, production of goods $\chi^d_{A,2}$ and $\chi^d_{F,2}$ are the same as in the case of free trade (see (12)). Given this, (6), (9) and current account[16], the usage of goods $Y^d_{A,2}$, $Y^d_{F,2}$ and Y^d_2 in Downstream also remains the same as in free trade. Therefore, we can focus on the equilibrium in Upstream and the fee income it implies.

From, (3), production function (2) and (**??**), the price index in Downstream is given by (10), where $p^u_{F,2} = p_{F,2}(1+\tau_F)$ and $p^u_{A,2} = p_{A,2}(1-\tau_A)$. This and (18) imply that τ_F is determined by τ_A[17]

$$1+\tau_F = (1-\tau_A)^{-\frac{\gamma}{1-\gamma}} \tag{29}$$

and the there is a positive relationship between these rates.[18]

Upstream trades and specializes in the A-good, if it invests in the technology of A-good and the wages in the A-sector exceed those in F-sector, i.e. $w^u_{A,2} \geq w^u_{F,2}$. Using the wages (14) and the world prices (18)

$$\left(\frac{1-\tau_A}{1+\tau_F}\right)^{\frac{1}{1-\alpha}} \bar{A} \geq 1.$$

This condition holding with an equality and (29) determines the maximum variable fee, τ^m_A, that Downstream can charge before Upstream reverts in autarky as

$$\tau^m_A = 1 - \frac{1}{\bar{A}^{(1-\alpha)(1-\gamma)}}. \tag{30}$$

and better technology in the A-sector (higher $\bar{A}$) allows higher maximum fees to be charged.

If Upstream invests in technology and $\tau_A < \tau^m_A$, it trades and fully specializes in the A-good. Using (12), (18), its production is

$$\chi^u_{A,2} = \left(\theta\alpha^2\right)^{\frac{\alpha}{1-\alpha}} F^{\alpha(1-\gamma)} (1-\tau_A)^{\frac{\alpha}{1-\alpha}} \bar{A};\ \chi^u_{F,2} = 0. \tag{31}$$

[16] The current account in the Upstream is $p_{A,2}(1-\tau_A)\left(Y^u_{A,2} - \chi^u_{A,2}\right) + p_{F,2}(1+\tau_F)\left(Y^u_{F,2} - \chi^u_{F,2}\right) = 0$ and the current account in the Downstream is $p_{A,2}\left(Y^d_{A,2} - \chi^d_{A,2}\right) + p_{F,2}\left(Y^d_{A,2} - \chi^d_{A,2}\right) + p_{A,2}\tau_A\left(Y^u_{A,2} - \chi^u_{A,2}\right) - p_{F,2}\tau_F\left(Y^u_{F,2} - \chi^u_{F,2}\right) = 0$

[17] This is driven by the normalization of the price of final good. In reality, the downstream country could choose the fees separately. However, if (29) does not hold, it leads to an adjustment of the upstream country's nominal exchange rate. By considering all variables in the units of final good, we have taken such exchange rate adjustment already into account.

[18] From (29), $\frac{d\tau_F}{d\tau_A} = \frac{\gamma}{1-\gamma} > 0$.

From (3), (18), (9) and (29) the usage of goods in Upstream is

$$Y^u_{A,2} = \gamma \left(\theta\alpha^2\right)^{\frac{\alpha}{1-\alpha}} F^{\alpha(1-\gamma)} \left(1-\tau_A\right)^{\frac{\alpha}{1-\alpha}} \bar{A} \tag{32}$$
$$Y^u_{F,2} = (1-\gamma) \left(\theta\alpha^2\right)^{\frac{\alpha}{1-\alpha}} F^{\alpha(1-\gamma)+1-\alpha} \left(1-\tau_A\right)^{\frac{\alpha}{1-\alpha}+\frac{1}{1-\gamma}} \bar{A}.$$

From here, (18) and (29) we can find the fee income of Downstream as

$$T^d_v = p_{A,2}\tau_A \left(\chi^u_{A,2} - Y^u_{A,2}\right) + p_{F,2}\tau_F Y^u_{F,2} = \tfrac{\Gamma\bar{A}(1-\gamma)}{1-\alpha} \left(1-\tau_A\right)^{\frac{\alpha}{1-\alpha}} \left(1 - \left(1-\tau_A\right)^{\frac{1}{1-\gamma}}\right), \tag{33}$$

where Γ is defined as in Lemma in 1.

Given that the profits and wages in Downstream do not depend on the fees, the optimal fees charged by the Downstream government solve

$$\tau^v_A = \max\left[\tau^*_A, \tau^m_A\right], \text{ where} \tag{34}$$
$$\tau^*_A = \arg\max\left[T^d_v\right], \ \tau^m_A \text{ is given by (30) and } T^d_v \text{ is given by (33)}$$

Lemma 6 *The optimal variable fee charged by Downstream is*

$$\tau^v_A = \begin{cases} \tau^*_A = 1 - \left(\frac{\alpha-\alpha\gamma}{1-\alpha\gamma}\right)^{1-\gamma} > 0 \ \textit{if} \ \tau^*_A \leq \tau^m_A \\ \tau^m_A \ \textit{if} \ \tau^*_A > \tau^m_A \end{cases} \tag{35}$$

Proof. If $\tau^*_A \leq \tau^m_A$, the problem (34) becomes $\tau^*_A = \arg\max\left[T^d_v\right]$, s.t. (33). Then from the first order condition of this, we obtain $\tau^v_A = \tau^*_A$ as in (35). If $\tau^*_A > \tau^m_A$, then $\tau^v_A = \max\left[\tau^*_A, \tau^m_A\right]$ gives $\tau^v_A = \tau^m_A$. ■

Lemma 6 implies that Downstream always charges positive fees. As long as the optimal fee is not the maximum one, i.e. $\tau^v_A \leq \tau^m_A$, 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 (33) it is clear that the fee income for Downstream is higher if the technology is better.

From (30) and (34) $\tau^*_A \leq \tau^m_A$ holds if and only if the quality of technology is sufficiently high, i.e. $\bar{A} > \left(\frac{1-\alpha\gamma}{\alpha-\alpha\gamma}\right)^{\frac{1}{(1-\alpha)}} > 1$. After a large improvement of technology, Upstream is willing to be open to trade even though it cannot sell its' products for the world equilibrium prices.[19]

[19] In the case where final goods production follows a more general CES production function, also lower substitutability between goods increases the likelyhood that the optimal fees are below the maximum ones that can be charged. Such an extension is available upon request.

Lemma 7 *Upstream invests in technology if the cost of technology investments*

$$I \leq I^v = \begin{cases} \hat{I} + \alpha\Gamma\bar{A}^\gamma \left(\left(\frac{1-\tau_A^*}{1-\tau_A^m} \right)^{\frac{1}{1-\alpha}} - 1 \right) > \hat{I} \text{ if } \tau_A^* \leq \tau_A^m \\ \hat{I} \text{ if } \tau_A^* > \tau_A^m \end{cases} \tag{36}$$

Provided that $I \leq I^v$ consumption in Upstream and the Downstream is, respectively

$$\begin{aligned} C_v^u &= \hat{C}^u \left(\bar{A}\right) + (1+\alpha)\Gamma\bar{A}^\gamma \left(\bar{A}^{1-\gamma} \left(\frac{1-\tau_A^v}{1-\tau_A^m} \right)^{\frac{1}{1-\alpha}} - 1 \right) \\ C_v^d &= C_{FT}^d \left(\bar{A}\right) + T_v^d. \end{aligned} \tag{37}$$

Proof. See Appendix B.3. ■

Lemma 7 shows that because the variable fees affect the profit of the technology firm directly, openness to trade does not lead to overinvestment in technology in Upstream. It is also worth to point out that trade in this case does not correct the market frictions that arise from underinvestment in technology in the autarkic equilibrium. The cost of investments that justifies the investment in technology under variable fees is always lower than it is in the case of free trade and fixed fees, i.e. $I^v < I^T$ (see(19) and (36)).[20] At the same time, investments in technology in Upstream are at least as likely as in autarky. If the technological improvement is large enough (such that $\tau_A^* < \tau_A^m$), both the probability of technology investments and consumption is higher than in autarky. In contrast, if Downstream charges the maximum fees, the likelihood of technology investments and consumption in Upstream is exactly the same as in autarky.

Similarly to the case of fixed fees, there is a potential time inconsistency. Namely, if $I^v < I < I^T$, Upstream does not invest in technology and Downstream does not benefit from the fees. Therefore, Downstream would like to commit to a lower fee in period 1 (since $\frac{dI^v}{d\tau_A^*} < 0$), that makes (36) hold with an equality. Given that this is no longer optimal in period 2, such fees are likely to be renegotiated.

2.3.4 Fixed vs. variable fees. A discussion.

While a realistic case may involve elements of both fixed and variable fees analyzing them separately highlights the importance of how fees affect the technology producers' incentives to invest. Notice that in the case of variable fees, Upstream may be better off than in autarky (see (37)). Therefore, if Downstream can charge both fixed and variable fees, it would

[20] More specifically, using (16) the threshold investment in free trade (19) can be expressed as $I^T = \hat{I} + \alpha\Gamma\left(\bar{A} - \bar{A}^\gamma\right)$. Using (30) in (36), $I^v = \hat{I} + \alpha\Gamma\left(\bar{A}\left(1-\tau_A^*\right)^{\frac{1}{1-\alpha}} - \bar{A}^\gamma\right)$ is clearly smaller than I^T.

extract this extra surplus, i.e. $(1+\alpha)\,\Gamma\bar{A}^{\gamma}\left(\bar{A}^{1-\gamma}\left(\frac{1-\tau_A^v}{1-\tau_A^m}\right)^{\frac{1}{1-\alpha}}-1\right)$ through a fixed fee.[21] In the model the fixed fee is a payment from the Upstream government to the Downstream government. In a wider setting they might be bribes to the ruling party in Downstream, costly support in a military conflict or supplying raw materials at below market prices. Variable fees may be tariffs, but clearly transport costs or bribes needed to pass road blocks are other costs that act as variable fees. In the extension that follows, we consider only variable fees to emphasize the link between ownership of firms and trade conditions. These effects do not depend on the magnitude of additional fixed fees.

2.4 Trade negotiations and foreign ownership of firms

So far, we assumed that firms investing in technology are always owned by local agents. In the case of variable fees, the firm's incentives to invest in technology and therefore the price of equity in that firm is directly affected by trade conditions.[22] Under capital mobility, this creates a potential relationship between trade conditions and ownership of the firms. The value of these firms is higher for investors from Downstream. To highlight the effect of ownership on optimal fees, we assume throughout this section that $\bar{A}$ is sufficiently high that the optimal fees are below the maximum fees Downstream can charge, i.e. $\tau_A^* < \tau_A^m$.

If investors from Downstream own the firm in Upstream, the profits that these investors earn from Upstream affect the optimal (variable) fees that Downstream charges. We focus on the case where investors from Downstream make a takeover investment at the end of period one, i.e. after the technology investments has been made and before the optimal variable fees are chosen by Downstream.[23]

Then consumption in Upstream and Downstream is given by

$$\begin{aligned}\tilde{C}^u &= w_1^u + w_2^u + \pi_1^d + \tilde{P}_\pi^u - I^u \\ \tilde{C}^d &= w_1^d + w_2^d + \pi_1^d + \pi_2^d + \left(\tilde{\pi}_2^u - \tilde{P}_\pi^u\right) + \tilde{T}_v^d - I^d\end{aligned} \tag{38}$$

respectively, where $\tilde{P}_\pi^u$ is the price of the technology producing firm at the end of period one, $\tilde{\pi}_2^u$ is the profit of the Upstream firm when owned by investors from Downstream and $\tilde{T}_v^d$ is

[21]Given that fixed fees do not reduce the incentives of technology producers in the upstream country to invest in technology, the downstream country would generally prefer only fixed fees.

[22]As seen in Section 2.3.1 the profits of technology firms, contingent on investment, is the same for all countries and independent of fixed fees. Under the efficient markets hypothesis the price of these firms must equal the profits and the value of these firms is exactly the same irrespectively who owns them. Under fixed fees the nationality of ownership therefore does not matter for the investment decision.

[23]A very similar argument holds for foreign investments from the downstream country in period 0, i.e. at the time where technology investments are made and is available upon request.

the fee income in such case.

The optimal fees in period 2 that maximize consumption in Downstream solve

$$\tilde{\tau}_A^* = \arg\max_{\tilde{\tau}_A} \left(\tilde{T}_v^d + \tilde{\pi}_2^u \right), \text{ where } \tilde{T}_v^d \text{ is given by (33) for } \tau_A = \tilde{\tau}_A. \tag{39}$$

If the technology firm in Upstream is owned by local investors, the profits in this firm are $\pi_2^u = \alpha \Gamma \bar{A} \left(1 - \tau_A^*\right)^{\frac{1}{1-\alpha}}$ (see Appendix B.3), where τ_A^* is given by (35). If it is owned by investors from Downstream, the profits are $\tilde{\pi}_2^u = \alpha \Gamma \bar{A} \left(1 - \tilde{\tau}_A\right)^{\frac{1}{1-\alpha}}$.

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 firmat 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 takeover investors in Downstream. For example, if there is just one potential takeover investor in Downstream then it can extract all excess profits and $\beta = 0$. Similarly, if there is perfect competition, i.e. are infinitely many investors from Downstream that buy the shares of the firms, then $\beta = 1$.

Lemma 8 *If investors from Downstream own the firm in Upstream, then the there is a unique solution for optimal fees $\tilde{\tau}_A^*$, such that*

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

Proof. See Appendix B.4. ■

The Downstream government takes the business interests of its residents into account

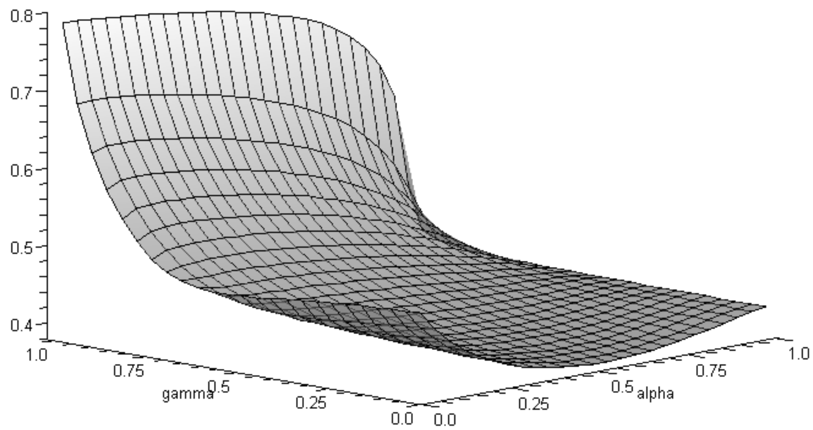

Figure 2: The threshold for the bargaining power $\bar{\beta}(\alpha, \gamma)$ that guarantees consumption gains for the downstream country.

Lemma 9 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)).

While consumers in Downstream receive lower revenue from the fees (see eq. (33)), 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 the Downstream, β.

Lemma 10 *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, $\tilde{C}_v^d \geq C_v^d$.*

Proof. See Appendix B.5. ■

Figure 2 plots the threshold value of bargaining power, $\bar{\beta}(\alpha, \gamma)$, that guarantees gains for consumers in Downstream. While the relationship is highly non-linear, it is clear that the likelihood of gains tend 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 positive [24] and there is a price for which selling the technology producing firms to the downstream investors benefits both countries.

[24] As $\bar{\beta}(\alpha, \gamma)$ 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).

While the Downstream may lose due to its firms investing in the Upstream, it can use additional policy instruments to avoid this. For example, it can impose a tax on the profits its investors 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 the 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 downstream investors do not buy these firms "too expensively".

3 Implications of the model and trade patterns.

The model suggests that while free trade increases income and the probability of investments in technology, a holdup problem makes a landlocked country poorer and less likely to invest in technology. If trade agreements are renegotiable and investment in technology is relatively costly, landlocked countries can be better off committing to stay in autarky. This implies

Using also the world equilibrium prices (18), we obtain that imports

$$Y_{F,2}^{u}-\chi_{F,2}^{u}=\left[(1-\tau_A)^{\frac{1}{1-\gamma}+\frac{\alpha}{1-\alpha}}\right]\cdot\left[(1-\tau_T)^{\frac{1}{1-\gamma}+\frac{\alpha}{1-\alpha}}\right]\cdot\left[(1-\gamma)\,F^{1-\gamma}\bar{A}\left(\theta\alpha^2\right)^{\frac{\alpha}{1-\alpha}}\right]$$

are a decreasing function of both the fees and transportation costs as well as the characteristics of trading partners (through $\bar{A}$, F and γ). 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).

$$\ln(imp)_{i,j,t}=\alpha X_{i,j,t}+\beta\tilde{\tau}_{T,t}+\gamma HU_{ij}, \tag{42}$$

where $X_{i,jt}$ 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 a landlocked country HU_{ij} is thus 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 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

$$\ln(imp)_{i,j,t}=\alpha X_{i,j,t}+\beta\tilde{\tau}_{T,t}+\gamma HU_{ij}+\delta HU_{ij}\cdot TA_{ijkt}, \tag{43}$$

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 $TA_{ijkt.}$

Does foreign ownership reduce the holdup problem?

Foreign ownership of assets in the Upstream is expected to reduce the holdup fees. We therefore estimate

$$\ln(imp)_{i,j,t}=\alpha X_{i,j,t}+\beta\tilde{\tau}_{T,t}+\gamma_i HU_i+\gamma_j HU_j+\gamma_{F,j}HU_j\cdot FDI\_liab_j+\delta_j FDI\_liab_j, \tag{44}$$

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 imports of 152 countries measured at 5 year intervals between 1950 and 2000. The data are downloadable from Shang-Jin Wei's website. 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. Imports are in US 1982-83 dollars. 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). The main new feature of the data is how distance is measured, as explained below.

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 and 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.

3.1.1 Measuring distance.

The literature that estimates gravity equations of trade has typically relied on distance measured as the great circle distance 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 is greater than that

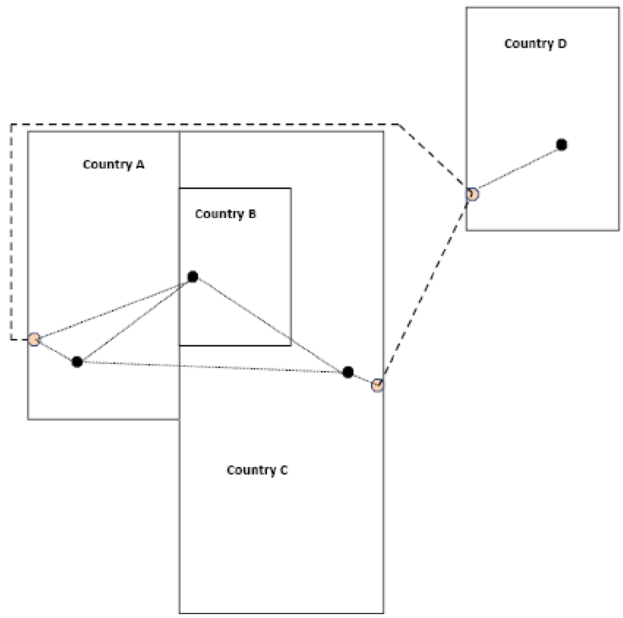

Figure 3: Illustation of measurement of distances.

of its transit country - something we would not capture with great circle distances.[25] We use Figure 3 to illustrate the implication of this for distance and trade of landlocked countries.[26] Consider trade between landlocked country B and country D. 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 D on the other hand - using great circle distances will assign a shorter bilateral distance between B and D than between A and D. Consider a case where was no holdup problem and where actual distances travelled by goods decrease trade: We would then erroneously conclude that trade between country B and D 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.

Measuring distance via the closest ports rather than as great circle distance is potentially important only if it captures important features of how trade takes place. Indeed Hummels (2007) reports that for non adjacent countries nearly all trade is by sea or air. For countries

[25] Depending on what 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.

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

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.

sharing a land border we therefore use great circle distances between main cities For nonadjacent countries air shipments would arguably roughly take the path of great circle between exporter and importer whereas trade by sea would minimize distance overland. Hummels (2007) reports that air shipment accounts for less than 1 percent of world trade when measured by weight. However, the role of air shipment has increased rapidly and products with a higher value to weight ratio are now more likely to be shipped by airplane - using data for the U.S. and 6 Latin American countries Hummels (2007) finds that around 30 percent of the value of imports arrive by air. Thus, since shipment by sea is still the dominant transport mode we use distances over the closest port to measure bilateral distances for nonadjacent countries. As our measure of main cities we use data from CEPII (Mayer and Zignago (2006)) which is also our source of distance measure between these main cities. Distance to the closest port is from www.findaport.com and distances between ports are from www.portworld.com. For a description of the data see the appendix C.

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. 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 0.8[27] This is an indication that the mismeasurement issue

[27] Using a t-test and Fischer's r to z transformation we can reject in each case that the correlations between

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***	-1.160***	-1.154***	-1.375***	-0.952***	-0.643***
	(0.0233)	(0.0242)	(0.0340)	(0.0401)	(0.104)	(0.0528)
Share of land in dist.			0.00754	-0.449	0.672	-0.112
			(0.403)	(0.418)	(0.674)	(0.593)
Holdup	-0.494***	-0.585***	-0.512***	-0.594***	-0.518***	0.0650
	(0.0995)	(0.0953)	(0.104)	(0.110)	(0.155)	(0.103)
Land border	0.0465	0.123	-0.313**	-0.253	0.538**	-0.649***
	(0.109)	(0.112)	(0.135)	(0.164)	(0.244)	(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.

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 above we report the results from estimating eq (42). 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

sea+land distance and great circle distances are the same for the trading relations subject to holdup and those that are not.

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 a mismeasurement of distance. 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. A closer look reveals that this variable is not the only high for the cases that feature really long overland stretches (say trade between the Kyrgyz Republic and its trading partners) but also for nearby trading partners with inland main cities (such as Iran and Saudi Arabia). Therefore we do not conclude that trading costs over land are not higher than over sea; we simply note that in a gravity regression, with these covariates, there is no systematic evidence that the land share has a robust relation to import volumes. 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. (43). There is no statistically significant effect of trade agreements with transit countries on trade flows. In column (3) we only examine the period after 1990 but the point estimate is still low and not significant.[28] 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 is among the few countries that are not yet members). 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 use FDI liabilities per capita for the exporter which we interact with the holdup dummy as in (44). 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

[28] Note 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***	-0.974***	-1.148***	-1.177***	-1.204***	-0.267***	-1.396***	-1.113***
	(0.0280)	(0.0280)	(0.0339)	(0.0353)	(0.0350)	(0.0143)	(0.0406)	(0.0415)
Share of	0.604*	0.602*	0.0334	-0.503	-0.484	-0.712***	-0.388	0.109
land in dist.	(0.320)	(0.320)	(0.374)	(0.384)	(0.384)	(0.140)	(0.416)	(0.394)
Holdup (HU)	-0.309***	-0.321***	-0.403***			-0.0973***	-0.563***	-0.431***
	(0.0428)	(0.0457)	(0.0524)			(0.0292)	(0.110)	(0.100)
Land border	0.111	0.111	0.350**	0.213	0.172	-0.103	-0.139	-0.0238
	(0.120)	(0.120)	(0.148)	(0.157)	(0.155)	(0.0692)	(0.164)	(0.151)
HU*fta		0.0436	0.0543					
		(0.0512)	(0.0599)					
HU_imp				-0.205***	-0.299***			
				(0.0513)	(0.0552)			
HU_exp				-0.395***	-0.374***			
				(0.0549)	(0.0549)			
HU_exp×					0.0128**			
FDI/CAP					(0.00620)			
FDI/CAP					0.0351***			
					(0.00233)			
Common	0.332***	0.332***	0.493***	0.539***	0.543***	0.118***		
language	(0.0431)	(0.0431)	(0.0514)	(0.0570)	(0.0537)	(0.0122)		
Inverse							0.0246	
Mills ratio							(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
						Pseudo R^2		
Root MSE	1.943	1.943	2.026	1.908	1.890		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.

a landlocked country is to increase trade by 11 percent (exp(0.0128*8.03)-1). As always, caution is adviced 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 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*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 landlocked country is subject to a holdup problem - after an investment has been made, the transit country will be tempted to extract all the rents it can from the landlocked country. Foreseeing this we are less likely to see technology investments in the landlocked country. One may believe that the issues concerning holdup of landlocked countries are so straightforward that no modelling is needed. We do not agree, because a lack of models and rigorous discussion about these issues 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.[29]

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 preoccupied with issues of (bargaining) strength. That coastal nations such as the UK, with 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. One is that 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. Nevertheless, a realistic model would include important frictions, such as the possibility of collusion between two downstream powers and infrastructure investment, and we leave that for future work.[30]

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

[30] Even a cursory look into the history of Bolivias access to the Pacific is one way to appreciate that such frictions may be substantial. See for instance "Pisco Sour", The Economist August 24 2006.

A Characteristics of Exports

	Coastal		Landlocked		Difference
Share of exports that are (excluding Europe)	Mean	Std err	Mean	Std err	coast-landl
Non-fuel primary commodities	49.28	3.07	71.46	5.18	-22.28***
Resource intensive manufactures	6.89	1.25	7.61	4.45	-0.72
Labor intensive manufactures	19.93	2.32	17.15	4.91	2.78
Differentiated products requiring specialized suppliers	9.93	1.39	3.16	0.92	6.77***
Scale-intensive manufactures	10.47	1.47	4.18	1.61	6.29***
Science based manufactures	4.92	0.73	1.14	0.36	3.77***
Share of exports that are differentiated (Rauch)					
All countries	41.09	2.52	29.71	4.94	11.38
Europe only	57.58	3.84	62.21	6.59	-4.43
non-Europe	36.38	2.89	20.23	4.52	16.05***
Africa	24.92	4.50	12.14	2.45	12.78***

This table presents two-sample t-test assuming unequal variances for the variables detailed in the left-most column. Trade 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. H0: landlocked and coastal are the same, "***" denotes that H0 can be rejected at 1% level.

B Proofs in the theoretical part

B.1 Proof of Lemma 1

From the labor market clearing condition $\hat{l}^i_{A,t} + \hat{l}^i_{F,t} = 1$, (9), (12), (13) and (15), we find the share of labor employed in the A-sector as $\hat{l}^i_{A,t} = \gamma$, output $\hat{\chi}^i_{A,t} = \hat{Y}^i_{A,t} = \gamma \left(\theta\alpha^2\right)^{\frac{\alpha}{1-\alpha}} \left(F/\hat{A}^i_t\right)^{\alpha(1-\gamma)} L^i A^i_t$ and $\hat{\chi}^i_{F,t} = \hat{Y}^i_{F,t} = (1-\gamma)\left(\theta\alpha^2\right)^{\frac{\alpha}{1-\alpha}} \left(F/\hat{A}^i_t\right)^{-\gamma\alpha} L^i F$, and profit $\hat{\pi}^i_t = \alpha\Gamma \left(\hat{A}^i_t\right)^{\gamma} L^i$. Using this, $\hat{A}^d_2 = \hat{A}^u_2 = \bar{A}$ and $\hat{A}^d_1 = \hat{A}^u_1 = 1$ in (8) gives (16). Using then (14), (15), and profit for $\hat{A}^w_2 = \hat{A}^w_2 = 1$ we obtain that consumption per capita in the rest of the world in autarky is $\bar{C}$. If Upstream and Downstream do not invest in technology in A-sector, they are identical to the rest of the world and their consumption per capita is $\bar{C}$. If they do invest in technology, then using again (14), (15), and profit together with (16) and $\bar{C}$, we obtain $\hat{C}^u\left(\bar{A}\right)$ and $\hat{C}^d\left(\bar{A}\right)$.

B.2 Proof of Lemma 2

Free trade implies that $p^i_{A,2} = p_{A,2}$ and $p^i_{F,2} = p_{F,2}$ for all i and current account is in balance in all countries, i.e. $p_{A,2}\left(Y^i_{A,2} - \chi^i_{A,2}\right) + p_{F,2}\left(Y^i_{F,2} - \chi^i_{F,2}\right) = 0$. This, together with relative prices (9) and the world market clearing conditions (6) imply the following relationship between production of specialized goods in the world $\frac{p_{A,t}}{p_{F,t}} = \frac{\gamma}{1-\gamma}\frac{Y^i_{F,t}}{Y^i_{A,t}} = \frac{\gamma}{1-\gamma}\frac{\chi^u_{F,2}+\chi^d_{F,2}+\chi^w_{F,2}}{\chi^u_{A,2}+\chi^d_{A,2}+\chi^w_{A,2}}$. Using these prices and the fact that Upstream and Downstream are fully specialized in (12) production in these countries is $\chi^u_{A,2} = \chi^d_{A,2} = \left(\theta\alpha^2\right)^{\frac{\alpha}{1-\alpha}} F^{(1-\gamma)\alpha}\bar{A}$ and $\chi^u_{F,t} = \chi^d_{F,t} = 0$. In the rest of the world, the labor shares allocated to each sector adjusts and we obtain that $l_{A,2} = \gamma - \frac{(1-\gamma)2\bar{A}}{L^w}$. Using this, (18) and $A^w_2 = 1$ in (12) and gives production in the rest of the world as $\chi^w_{A,t} = \left(\theta\alpha^2\right)^{\frac{\alpha}{1-\alpha}} F^{(1-\gamma)\alpha}\left(\gamma L^w - (1-\gamma)2\bar{A}\right)$ and $\chi^w_{F,t} = \left(\theta\alpha^2\right)^{\frac{\alpha}{1-\alpha}} F^{1-\gamma\alpha}\left((1-\gamma)L^w + (1-\gamma)2\bar{A}\right)$. Using then (14), (18), (13) and the definition of Γ in Lemma 1,, the wages and profits are $w^u_2 = w^d_2 = \Gamma\bar{A}$; $w^w_2 = \Gamma\bar{A}$ and $\pi^u_2 = \pi^d_2 = \alpha\Gamma\bar{A}$; $\pi^w_2 = \alpha\Gamma$. Using these in (8) and (1) proves the lemma.

B.3 Proof of Lemma 6

Using (13), the profit in Upstream in period 2 is $\pi^u_2 = \alpha\Gamma\bar{A}\left(1-\tau^v_A\right)^{\frac{1}{1-\alpha}}$. The investment in technology pays off if $I \leq \alpha\Gamma + \alpha\Gamma\bar{A}\left(1-\tau^v_A\right)^{\frac{1}{1-\alpha}}$. Using then (16) and the maximum fees (30), this can be written as $I \leq \hat{I} + \alpha\Gamma\bar{A}^{\gamma}\left(\left(\frac{1-\tau^v_A}{1-\tau^m_A}\right)^{\frac{1}{1-\alpha}} - 1\right)$. It is clear that $I \leq \hat{I}$ if $\tau^v_A \leq \tau^m_A$. Given Lemma 6, $\tau^v_A = \tau^*_A$ if $\tau^*_A \leq \tau^m_A$ and $\tau^v_A = \tau^m_A$ if $\tau^*_A > \tau^m_A$, which gives (36). From (1), (13), (14) consumption in Upstream is given by $C^u = (1+\alpha)\Gamma\bar{A}\left(1-\tau^v_A\right)^{\frac{1}{1-\alpha}} + (1+\alpha) - I$.Consumption in autarky is given by $\hat{C}^u\left(\bar{A}\right) = \Gamma + \alpha\Gamma + \Gamma\bar{A}^{\gamma} + \alpha\Gamma\bar{A}^{\gamma} - I$. Combining these and using (30), consumption in Upstream in given by (37). As the production and usage of goods in Upstream does not change, consumption there equals to the one in the case of free trade and fee income.

B.4 Proof of Lemma 8

It must hold that $\tilde{\tau}^*_A \in [0,1]$. Using (33) and $\tilde{\pi}^u_2 = \alpha\Gamma\bar{A}\left(1-\tilde{\tau}^*_A\right)^{\frac{1}{1-\alpha}}$ in (39), the first order condition can be written as

$$LHS\left(\tilde{\tau}^*_A\right) \equiv 1 - \tilde{\tau}^*_A = \left(\frac{\alpha - \alpha\gamma}{1-\alpha\gamma}\right)^{1-\gamma}\left(1 + \frac{1-\alpha}{1-\gamma}\left(1-\tilde{\tau}^*_A\right)\right)^{1-\gamma} \equiv RHS\left(\tilde{\tau}^*_A\right) \tag{45}$$

The slopes of $RHS\left(\tilde{\tau}^*_A\right)$ and $LHS\left(\tilde{\tau}^*_A\right)$ as both negative as $\frac{\partial LHS\left(\tilde{\tau}^*_A\right)}{\partial\tilde{\tau}^*_A} = -1 < 1$ and $\frac{\partial LHS\left(\tilde{\tau}^*_A\right)}{\partial\tilde{\tau}^*_A} = -\left(\frac{\alpha-\alpha\gamma}{1-\alpha\gamma}\right)^{1-\gamma}(1-\alpha)\left(1 + \frac{1-\alpha}{1-\gamma}\left(1-\tilde{\tau}^*_A\right)\right)^{-\gamma} < 0$. A sufficient condition for a

unique solution in such a case is that $\lim_{\tilde{\tau}_A^* \to 0} LHS(\tilde{\tau}_A^*) > \lim_{\tilde{\tau}_A^* \to 0} RHS(\tilde{\tau}_A^*)$ and $\lim_{\tilde{\tau}_A^* \to 1} LHS(\tilde{\tau}_A^*) < \lim_{\tilde{\tau}_A^* \to 1} RHS(\tilde{\tau}_A^*)$. This can be confirmed to hold. First, $\lim_{\tilde{\tau}_A^* \to 0} LHS(\tilde{\tau}_A^*) = 1$ and $\lim_{\tilde{\tau}_A^* \to 0} RHS(\tilde{\tau}_A^*) = \left(\frac{\alpha - \alpha\gamma}{1-\alpha\gamma}\right)^{1-\gamma}\left(1 + \frac{1-\alpha}{1-\gamma}\right)^{1-\gamma} = \left(\frac{\alpha(2-\gamma-\alpha)}{1-\alpha\gamma}\right)^{1-\gamma} < 1$, because $2\alpha - \gamma\alpha - \alpha^2 < 1 - \alpha\gamma \iff 0 < (1-\alpha)^2$, thus $\lim_{\tilde{\tau}_A^* \to 0} LHS(\tilde{\tau}_A^*) > \lim_{\tilde{\tau}_A^* \to 0} RHS(\tilde{\tau}_A^*)$. Second, $\lim_{\tilde{\tau}_A^* \to 1} LHS(\tilde{\tau}_A^*) = 0$ and $\lim_{\tilde{\tau}_A^* \to 1} RHS(\tilde{\tau}_A^*) = \left(\frac{\alpha-\alpha\gamma}{1-\alpha\gamma}\right)^{1-\gamma} > 0$. Therefore, there is a unique solution.

If firms in the Upstream are owned by the local investors there, then from (35) $LHS(\tau_A^*) = 1 - \tau_A^*$ and $RHS(\tau_A^*) = \left(\frac{\alpha-\alpha\gamma}{1-\alpha\gamma}\right)^{1-\gamma}$. Given that $\lim_{\tilde{\tau}_A^* \to 1} RHS(\tau_A^*) = RHS(\tilde{\tau}_A^*)$, 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 lemma.

B.5 Proof of Lemma 9

The investment in technology in the 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 (14), $\tilde{P}_\pi^u$ and (38), 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 8, it is straightforward that $(1-\tilde{\tau}_A^*)^{\frac{1}{1-\alpha}} - (1-\tau_A^*)^{\frac{1}{1-\alpha}} > 0$.

B.6 Proof of Lemma 10

Given that the takeover investments do not affect the production decisions in the 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 (33) 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 the 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 (33), $\tilde{\pi}_2^u$, π_2^u and the expressions for the optimal fees from (35) and (45), 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.

C 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 statis-

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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