Landlocked countries and holdup*

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Abstract

We develop a general equilibrium model where the trade of an upstream country with the rest of the world must pass through a downstream country. Investments to improve productivity can be made in a first period and in a second period there can be trade. We show that free trade increases income and the range of investment costs for which there will be investment. The opportunity for ex post opportunistic behaviour by the downstream country poses a holdup problem, which makes upstream countries poorer and less likely to invest in technology. We explore foreign ownership of upstream firms as a response to the holdup problem. We use gravity equations to examine predictions of the model, using actual distances via main ports rather than great circle distances. Our results point to that the potiential for holdup reduces trade by more than 50 percent. Free trade agreements with transit countries have only a weak effect on trade but the evidence isconsistent with foreign ownership lowering the holdup problem.

PRELIMINARY AND INCOMPLETE

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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

Many landlocked countries are strikingly poor: Outside Europe average gdp per capita in coastal economies is around 4900 USD whereas for landlocked countries it is a very harsh 600 USD[1]. Landlocked countries are also less developed than coastal economies in other aspects related to the quality of life and development (Collier (2007), Faye, Mcarthur, Sachs and Snow (2004), Gallup, Sachs and Mellinger (1999)). Why is this? It has previously been noted that landlocked countries trade less (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)) and face higher transport costs (Limão and Venables (2001), Raballand, Kunth and Auty (2005)). Recent micro evidence on the trade costs facing landlocked countries pointsto that longer overland distances per se are not the main reason for higher trande costs. For instance a recent 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 type of holdup problem that Adam Smith pointed to in the "Wealth of Nations" is relevant also for many landlocked developing countries today.

In this paper we build a simple general equilibrium model of trade. The main innovation is that we explicitly incorporate that an upstream country must trade through the downstream country to reach world markets in our model. The other main feature of our model is that firms have the potential to invest in new technology in a first period, after which trade potentially

[1] Average over 1995-2004 in 2000 USD dollars, source: World Development Indicators.

takes place in a second period. The ex ante investment makes the upstream country vulnerable to opportunistic behaviour by the downstream country ex post. We explore equilibrium transport fees and 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 whether fixed or variable transport fees are used. We show that free trade increases income and the range of investment costs for which there will be investment. The opportunity for ex post opportunistic behaviour by the downstream country poses a holdup problem, which makes upstream countries poorer and less likely to invest in technology. If trade agreements are renegotiable and investment costs are su¢ ciently high, the upstream country can be better off in autarky:When free trade is optimal for the landlocked country, it is worse off if it specializes in goods that are not easily substitutable within the country as it increases the fees that transit countries can extract..We extend the model to address the effect of foreign ownership of firms in the upstream country. A positive impact of foreign ownership on profitability of technology investments and GDP can arise purely from the fact that it generates more favourable trade conditions for an upstream country. This emphasizes the important effect of business interests on the trade lobby.

We proceed to examine the implications of the model on bilateral trade volumes using data for 1950-2000. The data set that we use is the same as in Subramanian and Wei (2007) but we replace the great circle distance ("as the crow flies") that they, and others in the gravity literature have used, with actual distances from main city to main city via the closest ports. These actual distances imply that the distance to all trading partners is greater for a landlocked country than it is for its transit country (apart from countries with which it shares a land border). Using great circle distances would thus assign too low distances to landlocked countries and we risk assigning lower trade to their landlocked status per se when in fact it would be longer distances that generated the lower trade. We also control for the share of distance that is on land. Our results point to that having to trade 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 liabilities to counterweigh the effect of the holdup problem. For free trade agreements there is a borderline significant positive effect while there is evidence that foreign ownership is associated with a weakening of the holdup effect. As indicated by the quote from the Wealth of Nations we are not the first to recognize the potential for hold up in this setting.[2] Indeed, arguments that

[2]History is replete with examples of countries that have put a high value on access to the sea. In the 16th and 17th century Sweden for instance had direct access to the

trade exposes you to opportunistic behavior by foreign powers have a deep history and are frequently heard in policy discussions. Nevertheless, holdup problems and issues of dependency are not part of the standard toolbox in international economics.[3] Arguably this is one reason why trade theory is not more succesful in persuading policy makers and the public of the benefits of free trade.[4] If the concerns of dependency are not in our models it is hard to be convincing about the tradeoffs faced. Even if one searches outside the mainstream international economics represented in text books there is only little formal study of dependency and international trade. McLaren (1997) is a notable exception and is the closest precursor.[5] He 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. In asymmetric settings the small country may have higher welfare in Autarky than if it specializes according to comparative advantage.[6] The intuition for this result is that by specializing the small country makes itself vulnerable to ex post opportunistic behaviour by the large country. Apart from explicit modelling of technology investment, a crucial difference in the current paper

Atlantic only via a small strip of land close to the present day Göteborg. This was lost to Denmark at two occasions and bought back through "Älsvsborgs lösen" where all Swedes had to pay 1/10 of their assets. Similarly, historians stress the value that Peter I of Russia placed on gaining access to the sea.

[3] There is essentially no explicit mention of arguments that by opening up for trade you expose yourself to the potential for foreign opportunistic behavior in for instance Feenstra (2004), Krugman and Obstfeld (2006) or Feenstra and Taylor (2008) .

[4] Much of the policy discussion acknowledges that there are potential gains from trade - but there is substantial role for fears that lower trade barriers makes one vulnerable to foreign exploitation. Standard theory shows that lower trade barriers are associated with higher wealth for a country. By trading freely countries can specialize according to comparative advantage, draw on scale economies and reap the benefits of increased product varieties and stronger competition (see for instance Feenstra (2004)). Empirically we know that richer countries also trade more and a substantial body of evidence points to that there are causal links from freeing trade to increased incomes. See for instance Frankel and Romer (1999) or Wacziarg and Welch (2008). Not everyone is convinced however: In the work of Rodrik, Subarmanian and Trebbi (2004) trade is not a significant correlate of incomes once the quality of institutions are accounted for. Instutions, just like trade, are not exogenous and disentangling the causal links between trade, institutions and income is an active research area. Acemoglu, Johnson and Robinson (2005) for instance argue that Atlantic trade strenghtened the merchant classes in Europe's Atlantic countries in the early modern period which allowed them to achieve a stronger protection of property rights.

[5] Even though informal, the work by Hirschman (1945) is another notable previous contribution. He examines how the Nazi regime in Germany used trade policy to wield power.

[6] McLaren (2002) examines regionalism vs free trade in a similar setting - investment decisions are made in period 1 and trade negotiations follow in period 2.

is that the hold up problem does not arise in our setting because of size differences.

By using the upstream and downstream terminology we also stress that there is a close link between these issues and the decision of make vs buy at the firm level (see for instance Coase (1937) or Grossman and Hart (1986) - Lafontaine and Slade (2007) survey the empirical evidence). A setting with relation specific investment has been applied to international trade in for instance Antràs and Helpman (2004), Grossman and Helpman (2005) or Ornelas and Turner (2008), see Helpman (2006) for a survey. These works do not focus on national trade policy however and the potential for holdup at the country level is not explored.

2 The model

Consider a two period economy in a world with three countries: upstream country, downstream country and the rest of the world, indexed with $i \in \{u, d, w\}$. Consumers in country i consume only in period 2.[7]

Each consumer in country i is endowed with one unit of labor each period and receives wage w_t^i in period t. The number of consumers/labor force in upstream and downstream country is the same and normalized to one $L^u = L^d = 1$ and substantially higher in the rest of the world $L^w >> 2$.

Consumption good (final good) is produced with constant elasticity of substitution technology

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

where $Y_{F,t}^i$ and $Y_{A,t}^i$ are specialized goods used in each country that cannot be directly used for consumption, $\epsilon \in [0, \infty)$ is elasticity of substitution between goods and $\gamma \in (0, 1)$. These goods are manufactured goods and F-good is produced using a more simple technology and A-good is produced with a potentially sophisticated technology. Normalizing the price of final good to one, final goods' sector minimizes the cost

$$\min_{Y_{F,t}^i, Y_{A,t}^i} Y_t^i = p_{F,t} Y_{F,t}^i + p_{A,t} Y_{A,t}^i \text{ st. } (1), \tag{2}$$

where $p_{F,t}$ and $p_{A,t}$ are the prices of good A and F respectively.

[7] 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.

Goods $Y^i_{F,t}$ and $Y^i_{A,t}$ can be traded across countries. There are no transport costs. However, the the trade of goods between upstream country and the rest of the world has to go through the downstream country. This gives downstream country an opportunity to change feed from upstream country. Final good, Y_t, can be traded as well. However, as this good is the same in all countries, the motivation for trading this good only arises from its role as a mean of payment.[8]

Specialized goods produced in each county are $\chi^i_{A,t}$ and $\chi^i_{F,t}$. The world market clearing implies that

$$\begin{aligned} \chi^w_{A,t} + \chi^u_{A,t} + \chi^d_{A,t} &= Y^w_{A,t} + Y^u_{A,t} + Y^d_{A,t} \\ \chi^w_{F,t} + \chi^u_{F,t} + \chi^d_{F,t} &= Y^w_{F,t} + Y^u_{F,t} + Y^d_{F,t} \end{aligned} \tag{3}$$

Specialized goods have Cobb-Douglas production function

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

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

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

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 $j \in \{A, F\}$.

The capital for both sectors is produced using the final good and depreciates fully in one period. Both capital goods are produced by the same monopolistic capital producer[9] (who is also and engineer or employs an engineer with no agency problems), who uses one unit of final good to produce one unit of capital good in each sector

$$\max_{x^i_{A,t}, x^i_{F,t}} \pi^i_t = \sum_{j=A,F} p^i_{x,j,t} x^i_{j,t} - x^i_{j,t} \text{ st. } \frac{\partial p^i_{x,j,t}}{\partial x^i_{j,t}}, \tag{6}$$

[8] We implicitly assume that the final good can be costlessly transformed from a physical good into money and back. It can also be costlessly transported between downstream country and the rest of the world (though it does not happen in the equilibrium we analyze).

[9] The assumption of the same owner is to abstract from the straightforward effect of specialization in a particualr good to incentives to invest in technology in that sector.

The initial quality of technology is given, the same all countries and normalized to one $F_1^i = A_1^i = 1$ for every i. Technology in sector F cannot improved and $F_2^i = 1$.[10] Both, in upstream country and downstream the engineer has an "idea" how to improve the quality of capital goods for sector A. 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

$$\pi_2^i(\bar{A}, 1) - \pi_2^i(1, 1) \geq I. \tag{7}$$

We assume that there are no such engineers in the rest of the world and $A_2^w = 1$ and they cannot copy the technology.[11] This allows upstream and downstream country to develop a comparative advantage in producing A-good and gives motivation for these countries to trade with the rest of the world in period 2.

Governments of upstream country and downstream country engage in trade negotiations in period 1. The objective of government is assumed to be maximizing to consumption (here equivalent to welfare) of local consumers. We consider various possibilities: fixed fees with no commitment, fixed fees with commitment and variable fees that depend on the volume of goods passing through downstream country. The potential income from these fees is distributes as lump sum transfers (in terms of final good) to consumers in downstream country. If upstream needs to tax its agents (in the case of fixed fees), it also applies lump sum taxes to its consumers. Such net lump sum transfers are denoted with, T^i.

Note that the transfers could be also used to subsidize investments in technology as the monopolistic power in capital goods production for sector A is subject to monopoly distortions. Addressing this friction is not in the scope of the paper and does not affect the conclusions.

The average per capita consumption in country i

$$\frac{C^i}{L^i} = w_1^i + w_2^i + \frac{\pi_1^i + \pi_2^i + T^i - \tilde{1}_I^i I + \Phi_\pi^i}{L^i} \tag{8}$$

where T^i is the net transfers from government. The term $\tilde{1}_1^i I_1^i$ indicates investment in technology, where $\tilde{1}_1^i = 1$ if an investment is made and is zero otherwise.

[10] Allowing for the monopolistic power in production of capital for sector F and agents who are able to do so in the rest of the world or in all countries would not alter the results of the model.

[11] We can think that it takes too much time for the knowledge to become available for the agents in the rest of the world. An alternative setup would be to assume that engineers in the rest of the world have better skills in developing technology F and it does not pay off to invest in technology A there.

The last term, Φ_π, indicates any gains or losses from owning equity in another country or foreign agents buying local equity. Until Section ??? we assume that firms in all country are owned by local consumers only and $\Phi^i_\pi = 0$.

2.1 Production decisions

Before proceeding to analyze equilibrium results in autarky and in the world economy, we can solve the problem of producers in different sectors. The cost minimization problem (2) gives the relationship between relative prices and demand of good A and F

$$\frac{p^i_{A,t}}{p^i_{F,t}} = \frac{\gamma}{1-\gamma}\left(\frac{Y^i_{A,t}}{Y^i_{F,t}}\right)^{-\frac{1}{\epsilon}} \tag{9}$$

and price index is

$$\left(\gamma^\epsilon\, {p^i_{A,t}}^{1-\epsilon} + (1-\gamma)^\epsilon\, {p^i_{F,t}}^{1-\epsilon}\right)^{\frac{1}{1-\epsilon}} = 1. \tag{10}$$

Using (9), (10) and the production function of the final good (1)

$$Y^i_t = \gamma^{-\epsilon} Y^i_{A,t}\, {p^i_{A,t}}^{\epsilon}. \tag{11}$$

The first order conditions of specialized producers' problem gives wages

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

and demand of capital for sector j that is linear in the quality of respective technology $x^i_{A,t} = \alpha^{\frac{1}{1-\alpha}} \left(\frac{p^i_{A,t}}{p^i_{x,A,t}}\right)^{\frac{1}{1-\alpha}} l^i_{A,t} L^i A_t$ and $x^i_{F,t} = \alpha^{\frac{1}{1-\alpha}} \left(\frac{p^i_{F,t}}{p^i_{x,F,t}}\right)^{\frac{1}{1-\alpha}} l^i_{F,t} L^i F$. From capital goods sector maximization (6) problem we then obtain the price of capital goods $p^i_{x,A,t} = 1$ and $p^i_{x,F,t} = 1$. Using these in (4), the output of specialized goods is

$$\chi^i_{A,t} = \alpha^{\frac{\alpha}{1-\alpha}} \left(p^i_{A,t}\right)^{\frac{\alpha}{1-\alpha}} l^i_{A,t} L^i A^i_t, \tag{13}$$

$$\chi^i_{F,t} = \alpha^{\frac{\alpha}{1-\alpha}} \left(p^i_{F,t}\right)^{\frac{\alpha}{1-\alpha}} l^i_{F,t} L^i F. \tag{14}$$

The profit of A-sector's capital producing firm (call it "technology firm") is

$$\begin{aligned} \pi^i_t &= \alpha\Gamma\left[\left(p^i_{A,t}\right)^{\frac{1}{1-\alpha}} l^i_{A,t} A_t + \left(p^i_{F,t}\right)^{\frac{1}{1-\alpha}} l^i_{F,t} F\right] L^i, \text{ where} \\ \Gamma &\equiv (1-\alpha)\, \alpha^{\frac{\alpha}{1-\alpha}} \end{aligned} \tag{15}$$

2.2 Autarky

In autarky (the autarky variables are denoted with a "hat"), both specialized goods are produced in each country i and $\hat{\chi}^i_{F,t} = \hat{Y}^i_{F,t}$, $\hat{\chi}^i_{A,t} = \hat{Y}^i_{F,t}$ for every i. Equating the wages in both sector (12), $w^i_t = w^i_{A,t} = w^i_{F,t}$

$$\frac{\hat{p}^i_{A,t}}{\hat{p}^i_{F,t}} = \frac{\hat{\chi}^i_{F,t}\hat{l}^i_{A,t}}{\hat{\chi}^i_{A,t}\hat{l}^i_{F,t}}. \tag{16}$$

Using the specialized good production ((13), (14)) implies that relative price of specialized goods depends on the relative quality of technologies

$$\frac{\hat{p}^i_{A,t}}{\hat{p}^i_{F,t}} = \left(\frac{F}{\hat{A}^i_t}\right)^{1-\alpha} \tag{17}$$

higher quality of technology in a particular specialized sector implies lower prices of the specialized good. Therefore, if upstream and downstream countries invest in technology, the relative price of A-good falls in this country.

Using $F = 1$, (17) and the price index (10), the prices of goods are given by

$$\begin{aligned} \hat{p}^i_{A,t} &= \left(\frac{\hat{\Theta}^i_t}{\hat{A}^i_t}\right)^{(1-\alpha)} \\ \hat{p}^i_{F,t} &= \hat{\Theta}^{i\,(1-\alpha)}_t, \end{aligned} \tag{18}$$

where

$$\hat{\Theta}^i_t \equiv \left(\gamma^\epsilon\, \hat{A}^{i\,(1-\alpha)(\epsilon-1)}_t + (1-\gamma)^\epsilon\right)^{\frac{1}{(1-\alpha)(\epsilon-1)}}. \tag{19}$$

From labor market clearing condition $\hat{l}^i_{A,t} + \hat{l}^i_{F,t} = 1$, (9), (16) and (17), we can find the share of labor employed in A-sector as

$$\hat{l}^i_{A,t} = \gamma^\epsilon \left(\frac{\hat{A}^i_t}{\hat{\Theta}^i_t}\right)^{(1-\alpha)(\epsilon-1)} \tag{20}$$

Using this and prices of A-good and F-good in (13), (14) and (11), we can find output of A-good, F-good and final good as

$$\begin{aligned} \hat{Y}^i_t &= \alpha^{\frac{\alpha}{1-\alpha}}\hat{\Theta}^i_t L^i \\ \hat{\chi}^i_{A,t} &= \gamma^\epsilon \alpha^{\frac{\alpha}{1-\alpha}}\, \hat{A}^{i\,\epsilon(1-\alpha)}_t\, \hat{\Theta}^{i\,1-\epsilon(1-\alpha)}_t\, L^i \\ \hat{\chi}^i_{F,t} &= (1-\gamma)^\epsilon\, \alpha^{\frac{\alpha}{1-\alpha}}\, \hat{\Theta}^{i\,1-\epsilon(1-\alpha)}_t\, L^i \\ \hat{w}^i_1 &= (1-\alpha)\,\alpha^{\frac{\alpha}{1-\alpha}}\hat{\Theta}^i_t = \Gamma\hat{\Theta}^i_t \end{aligned} \tag{21}$$

The profit of technology sector is given by

$$\hat{\pi}_t^i = \alpha\Gamma\hat{\Theta}_t^i\hat{L}^i.$$

and profit is increasing in $\hat{A}_t^i$.[12]

Given that all countries have identical technology in period 1

$$\eta \equiv \hat{\Theta}_1^i = (\gamma^\epsilon + (1-\gamma)^\epsilon)^{\frac{1}{(1-\alpha)(\epsilon-1)}} < 1 \tag{22}$$

and prices are equal across sectors and countries in period 1. Also, the technology cannot improve in the rest of the world making constant prices in the rest of the world.

$$\hat{p}_{A,1}^i = \hat{p}_{F,1}^i = \hat{p}_{A,1}^w = \hat{p}_{F,1}^w = \eta^{(1-\alpha)}$$

From (21) this implies that production in A-sector and F-sector is the same.

Profits in the rest of the world and in period 1 in upstream and downstream country are identical

$$\frac{\hat{\pi}_{A,1}^w}{L^w} = \frac{\hat{\pi}_{A,2}^w}{L^w} = \hat{\pi}_{A,1}^u = \hat{\pi}_{A,1}^d = \alpha\Gamma\eta$$

If upstream and downstream country invest in technology

$$\hat{A}_\Theta \equiv \hat{\Theta}_1^u = \hat{\Theta}_1^d = \left(\gamma^\epsilon\ \bar{A}^{(1-\alpha)(\epsilon-1)} + (1-\gamma)^\epsilon\right)^{\frac{1}{(1-\alpha)(\epsilon-1)}}$$

Observe that

$$\eta < \hat{A}_\Theta < \eta\bar{A}. \tag{23}$$

If the countries invest in technology, the prices of A-good fall and F good increase

$$\begin{aligned} \hat{p}_{A,2}^u\left(\bar{A}\right) &= \hat{p}_{A,2}^d\left(\bar{A}\right) = \left(\frac{\hat{A}_\Theta}{\bar{A}}\right)^{(1-\alpha)} < \eta^{(1-\alpha)} = \hat{p}_{A,1}^i \\ \hat{p}_{F,2}^u\left(\bar{A}\right) &= \hat{p}_{F,2}^d\left(\bar{A}\right) = \hat{A}_\Theta^{(1-\alpha)} > \hat{p}_{F,1}^i \end{aligned}$$

The profit of upstream and downstream country when investing in technology is

$$\hat{\pi}_2^u\left(\bar{A},1\right) = \hat{\pi}_2^d\left(\bar{A},1\right) = \alpha\Gamma\hat{A}_\Theta,$$

[12] $\frac{\partial\hat{\pi}_t^i}{\partial\hat{A}_t^i} = \alpha\Gamma\ \hat{\Theta}_t^{i\ \frac{1}{(\epsilon-1)(1-\alpha)}-1}\ \hat{L}^i\gamma^\epsilon\ \hat{A}_t^{i\ (1-\alpha)(\epsilon-1)-1} > 0$

Upstream and downstream countries make an identical decision whether to invest in technology. Using (7) and the results in this section, both countries invest in technology investment is below a threshold

$$I \leq \hat{I},\ \hat{I} = \alpha\Gamma\left(\hat{A}_{\Theta} - \eta\right) \tag{24}$$

With A-good and F-good being substitutes, $\hat{I} > 0$. This highlights the importance of assuming the goods being substitutes. If the goods were complements, there would be no incentives to invest in improving technology for producing A-good as there would be too big fall of demand for that good.

Consumption per capita in the rest of the world is

$$\frac{C^w}{L^w} = \Gamma\left(2\eta + 2\alpha\eta\right). \tag{25}$$

If $I < \hat{I}$, then per capita consumption in upstream and downstream countries is $\hat{C}^d = \hat{C}^u = \frac{\hat{C}^w}{L^w}$. When it pays off to invest in technology in these countries, their consumption is higher

$$\hat{C}^d = \hat{C}^u = \Gamma\left(\eta + \hat{A}_{\Theta} + 2\alpha\eta\right) + \hat{I} - I. \tag{26}$$

2.3 Free trade

Assume that downstream country does not impose any fees on upstream country. As there is no trade in period 1, period 1 results are the same as in autarky. In period 2, there can be gains from trade, because upstream and downstream countries can develop a comparative advantage in production of A-good. Suppose that this is the case and $A_2^d = A_2^u = \bar{A}$. Free trade implies that $p^i_{A,2} = p_{A,2}$, $p^i_{F,2} = p_{F,2}$ for all $i \in \{u, d, w\}$.

Current account has to be in balance in all countries. This implies that

$$p_{A,2}\left(Y^i_{A,2} - \chi^i_{A,2}\right) + p_{F,2}\left(Y^i_{F,2} - \chi^i_{F,2}\right) = 0 \tag{27}$$

Using (3), (9), (10) and (27), we obtain

$$\frac{p_{A,2}}{p_{F,2}} = \left(\frac{Y^i_{A,2}}{Y^i_{F,2}}\right)^{-\frac{1}{\epsilon}} = \frac{\gamma}{1-\gamma}\left(\frac{\chi^w_{A,2} + \chi^u_{A,2} + \chi^d_{A,2}}{\chi^w_{F,2} + \chi^u_{F,2} + \chi^d_{F,2}}\right)^{-\frac{1}{\epsilon}} \tag{28}$$

As the rest of the world is assumed to be substantially bigger than upstream and downstream country together[13], these countries specialize completely in production of A-good ($l^u_{A,2} = l^d_{A,2} = 1$), while the rest of the world

[13] To be specific, it must hold that $L^w > \frac{\eta^{\alpha}(1-\gamma)^{\epsilon}}{\gamma^{\epsilon}} 2\bar{A}$

specializes incompletely in production of F-good. As the countries are identical they produce the same quantity of specialized good $\chi^u_{A,2} = \chi^d_{A,2}$ and no F-good $\chi^u_{F,2} = \chi^d_{F,2} = 0$, the price of good A from (13) is

$$p_{A,2} = \frac{1}{\alpha}\left(\frac{\chi^u_{A,2}}{\bar{A}}\right)^{\frac{1-\alpha}{\alpha}} = \frac{1}{\alpha}\left(\frac{\chi^d_{A,2}}{\bar{A}}\right)^{\frac{1-\alpha}{\alpha}}.$$

As the rest of the world produces both goods, the wages $w^w_{A,2} = w^w_{F,2}$ and relative prices must satisfy

$$\frac{p_{A,2}}{p_{F,2}} = \left(\frac{F}{A}\right)^{1-\alpha} = 1. \tag{29}$$

The price of F-good is therefore $p_{F,2} = \frac{1}{\alpha}\left(\frac{\chi^u_{A,2}}{\bar{A}}\right)^{\frac{1-\alpha}{\alpha}}$. Using the price index (10), (22) and the above prices we can find equilibrium prices and the demand for goods produced in upstream and downstream country as

$$\begin{aligned} p_{A,2} &= p_{F,2} = \eta^{(1-\alpha)} \\ \chi^d_{A,2} &= \chi^u_{A,2} = \alpha^{\frac{\alpha}{1-\alpha}}\eta^{\alpha}\bar{A} \end{aligned} \tag{30}$$

Compared to autarky in upstream and downstream, the relative price of A-good is lower leading to higher demand of A-good.

The prices are the same as in autarky in the rest of the world due to the fact that the rest of the world continues production of both goods. The share of labor allocated to each sector adjusts to changed demand for the specialized products and the wages remain equal across sectors. We can find the share of labor in A-sector of the rest of the world using the prices and demand for upstream and downstream country production and (13), (14) in (28)

$$l^w_{A,t} = \frac{\gamma^{\epsilon}}{\eta^{(1-\alpha)(\epsilon-1)}} - \frac{(1-\gamma)^{\epsilon}\, 2\bar{A}}{L^w \eta^{(\epsilon-1)(1-\alpha)}}$$

and production of specialized goods

$$\begin{aligned} \chi^w_{A,2} &= \gamma^{\epsilon}\alpha^{\frac{\alpha}{1-\alpha}}\eta^{1-\epsilon(1-\alpha)}L^w - \alpha^{\frac{\alpha}{1-\alpha}}\eta^{1-\epsilon(1-\alpha)}(1-\gamma)^{\epsilon}\, 2\bar{A} \\ \chi^w_{F,2} &= (1-\gamma)^{\epsilon}\alpha^{\frac{\alpha}{1-\alpha}}\eta^{1-\epsilon(1-\alpha)}L^w + \alpha^{\frac{\alpha}{1-\alpha}}\eta^{1-\epsilon(1-\alpha)}(1-\gamma)^{\epsilon}\, 2\bar{A} \end{aligned} \tag{31}$$

Using this with (29) and (28) $\frac{Y^i_{A,2}}{Y^i_{F,2}} = \frac{\chi^w_{A,2}+\chi^u_{A,2}+\chi^d_{A,2}}{\chi^w_{F,2}+\chi^u_{F,2}+\chi^d_{F,2}} = \frac{\gamma^{\epsilon}}{(1-\gamma)^{\epsilon}}$. From current account in each country and (11) we can then find output of final good in country as

$$\begin{aligned} Y^u_2 &= Y^d_2 = \alpha^{\frac{\alpha}{1-\alpha}}\bar{A}\eta \\ Y^w_2 &= \alpha^{\frac{\alpha}{1-\alpha}}\eta L^w \end{aligned}$$

and wages and profit as

$$
\begin{aligned}
w_2^u &= w_2^d = \Gamma \bar{A} \eta;\ w_t^w = \Gamma \eta \\
\pi_2^u &= \pi_2^d = \alpha \Gamma \bar{A} \eta;\ \pi_2^w = \alpha \Gamma \eta.
\end{aligned}
$$

Despite changes in the production of A-good and F-good in the rest of the world, the wages and profits remain at the same level as in autarky.

The threshold for investment in technology is

$$I \leq I^T = \alpha \Gamma \left(\eta \bar{A} - 1 \right) \tag{32}$$

The threshold level that justifies investment is higher than in autarky $I^T > \hat{I}$ (23). In the interval $I \in (\hat{I}, I^T]$ investment in technology can occur only because of a decision to be open the trade.

If $I < I^T$, consumption increases in upstream and downstream above the level in autarky, while staying constant in the rest of the world

$$
\begin{aligned}
\frac{C^w}{L^w} &= \Gamma \left(2\eta + 2\alpha\eta \right) = \frac{\hat{C}^w}{L^w} \qquad (33) \\
C^u &= C^d = \Gamma \left(\eta + \bar{A}\eta + 2\alpha\eta \right) + I^T - I > \hat{C}^u = \hat{C}^d
\end{aligned}
$$

2.4 Trade negotiations

Previous section showed that the possibility to innovate in A-sector, gives both to upstream country and to downstream country an opportunity to gain from free trade. In what follows, it is assumed that the required investment to innovate is always sufficiently high to pay off if trade is free $I < I^T$ (32), therefore downstream country always invests in technology.

As there are no frictions between downstream country and the rest of the world, trade is always free between these countries. While we assume that there are no actual transport costs, the location of downstream countries gives it an opportunity to charge various types of fees from downstream country. The objective governments in upstream country and downstream country is assumed to be maximizing the average consumption of local agents. Unless specified otherwise we assume, that only local agents own the profit of local firms.

2.4.1 Fixed fee

Suppose that the downstream country can charge a fixed fee in terms of final good from the government of downstream country. This fee will be distributed as a lump sum transfer among the consumers in downstream country in period 2. Upstream country finances this fee as a lump sum tax, from local consumers. As the fee is fixed, it does not alter the decisions of producers in either country in if upstream country decides to trade freely.

No commitment

Assume that the magnitude of the fixed fee cannot be determined before firms in upstream country decide whether to invest in technology. This implies that trade negotiations happen either after local monopolists have made their decision to invest in technology or the fee can be renegotiated even though it was agreed before technology investments were made.

Suppose that technology sector in upstream country invests in technology, $A_2^u = \bar{A}$. In period 2, the threat point of upstream country is to stop the free trade. In such case consumption in upstream country is given by $\hat{C}^u\left(\bar{A}\right)$ (**??**), i.e. autarky level with investment in technology. Using this with (33), the maximum fee upstream country is willing to pay must satisfy

$$-T^u_{fix\_nc} \geq \hat{C}^u(\bar{A}) - C^u = \Gamma\left(\hat{A}_\Theta - \bar{A}\eta\right) + \hat{I} - I^T \qquad (34)$$

To enforce the collection of fees, upstream country can forbid any goods traded between upstream and downstream country to pass through the country before the fixed fee paid.

Given the assumption that the rest of the world is sufficiently big, the decision of upstream country to trade of not with the rest of the world does not affect the equilibrium relative prices, and production of specialized goods in downstream country[14]. This implies that downstream country can maximize consumption in its country by maximizing the fee $\max T^d_{fix\_nc} = T^u_{fix\_nc}$, subject to (34). As the location gives upstream country all bargaining power (34) is binding.

Using (26), (33) and (34) consumption in upstream and downstream is therefore

$$
\begin{aligned}
C^u_{fix\_nc} &= C^u - T^u_{fix\_nc} = \Gamma\left(\eta + \hat{A}_\Theta + 2\alpha\eta\right) + \hat{I} - I \\
C^d_{fix\_nc} &= C^d + T^d_{fix\_nc} = \Gamma\left(\eta + 2\eta\bar{A} - \hat{A}_\Theta + 2\alpha\eta\right) + \left(2I^T - I - \hat{I}\right)
\end{aligned}
$$

As $\eta\bar{A} > \hat{A}_\Theta$ and $I^T > \hat{I}$ consumption in downstream country is strictly higher. In upstream country, consumption is the same as in autarky if $I < \hat{I}$. However, if $\hat{I} < I < I^T$, i.e. the investment in technology does not pay off in autarky. Consumers in upstream country are worse off with trade iff $C^u_{fix\_nc} < \Gamma\left(2\eta + 2\alpha\eta\right)$, which simplifies to

$$
\hat{I}_{fix\_nc} < I < I^T, \text{ where } \hat{I}_{fix\_nc} = \hat{I} + \Gamma\left(\hat{A}_\Theta - \eta\right). \qquad (35)
$$

If upstream country does not invest in technology in period 1, it will be identical to the rest of the world economy apart from its size. As it was shown in Section ???, the rest of the world consumption with free trade is the same as in autarky. Therefore, downstream country cannot charge any fixed fees from upstream country and upstream country is indifferent between being open to trade or not (notice that this is off equilibrium, as with fixed fees, upstream country would not invest in technology only if $I > I^T$ where downstream also does not invest and there are no gains from trade).

Therefore there are four possible outcomes in upstream country that depends on the cost of investment

- $I < \hat{I}$ Downstream country would invest in technology in autarky and does not lose from trading even though consumers in downstream are richer in the expense of consumers in upstream
- $\hat{I} < I < \hat{I}_{fix\_nc}$ Trade encourages investment in technology that would not occur in autarky and downstream country gains from openness to

[14]Only thing that changes is the share of labor in A-sector in the rest of the world, which is easy to show as in the case of free trade not to affect production of final good, wages and profits.

trade. This gain arises from the fact that the social gains from better technology are higher than the gains of monopolistic firms (through higher wages). As trade increases the market for innovative products in local market (labor works in A-sector), it increases the incentives to develop technology. The same outcome would occur if government would subsidize investments in technology with lump sum taxes from consumers. (this feature common in all endogeneous growth models e.g. Romer,1990). However, one could imagine a situation, where government subsidies involve agency problems, which can be overcome with openness to trade, even though downstream country uses its location to extract a part of the benefits of trade.

- $\hat{I}_{fix\_nc} < I < I^T$ Openness to trade makes upstream country worse off. As investment in technology is made before the fixed fees are decided. Location determined monopolistic power and lack of commitment allows downstream country to charge too high fees. Upstream country would be better off if it decides to no be open to trade. Therefore, government decides in period 1 not to be open to trade, and the level of technology in upstream is lower than in downstream.

- $I > I^T$ no country invests in technology and there are no gains from trade.

Commitment

Given the results in the no commitment part, it is clear that commitment problems are important if $\hat{I}_{fix\_nc} < I < I^T$. In all other cases, upstream would be willing to accept $T^u_{fix\_nc}$ even if the fee is decided before the technology investments are made in the upstream country. Assume here that upstream country and downstream country decide and commit for a fixed fee before technology investment decisions are made in upstream country.

If $\hat{I}_{fix\_nc} < I < I^T$ downstream country would get a loss $\Lambda = \hat{C}^u(\bar{A}) - \Gamma(2\eta + 2\alpha\eta)$. Using (26) and (35) this becomes $\Lambda = \hat{I}_{fix\_nc} - I$. Fixed fee with commitment has to satisfy both the condition that upstream country does not switch to autarky in period 2 and becomes open to trade in period 1. This implies the following two conditions for the fixed fee

$$\begin{aligned} C^u - T^u_{fix\_nc} &\geq \hat{C}^u(\bar{A}) \\ C^u - T^u_{fix\_nc} &\geq \hat{C}^u(\bar{A}) + I - \hat{I}_{fix\_nc}. \end{aligned}$$

When $I > \hat{I}_{fix\_nc}$, the second condition is more restrictive and given the bargaining power of downstream country holds with equality. This implies the following consumption in upstream and downstream country

$$\begin{aligned} C^u_{fix\_c} &= \Gamma\left(\eta+\hat{A}_\Theta+2\alpha\eta\right)+\hat{I}-\hat{I}_{fix\_nc} \\ C^d_{fix\_c} &= \Gamma\left(\eta+2\eta\bar{A}-\hat{A}_\Theta+2\alpha\eta\right)+\left(2I^T-2I-\hat{I}+\hat{I}_{fix\_nc}\right)= \\ &= \Gamma\left(2\eta\bar{A}+2\alpha\eta\right)+\left(2I^T-2I\right) \end{aligned}$$

In this case, upstream country gains from trade as $\hat{I} \geq \hat{I}_{fix\_nc}$. Also downstream country gains from the downstream countries openness to trade $I^T > I$ and $2\eta\bar{A} > \eta$. However, the commitment problem on downstream country is reflected in the fact that $C^d_{fix\_nc} > C^d_{fix\_c}$, which clearly implies time inconsistency of commitment.

In all cases, consumers in downstream country have higher consumption than in downstream.

2.4.2 Variable fees

Suppose that instead a fixed fee the downstream country charges a variable fee on A-good and F-good that pass through the country. In particular, it buys F-good from the rest of the world for a price $p_{F,2}$ and sells these to upstream country for a price $p_{F,2}(1+\tau_F)$. Similarly, it buys A-good from upstream country for $p_{A,2}(1-\tau_A)$ and sells it to the rest of the world for $p_{A,2}$.

This implies that the current account in upstream country 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 in downstream country is

$$\begin{aligned} p_{A,2}\left(Y^d_{A,2}-\chi^d_{A,2}\right)+p_{A,2}\left(Y^u_{A,2}-\chi^u_{A,2}\right)-p_{F,2}(1+\tau_F)\left(Y^u_{F,2}-\chi^u_{F,2}\right)+ & \\ p_{F,2}\left(Y^d_{F,2}-\chi^d_{F,2}\right)-p_{A,2}(1-\tau_A)\left(Y^u_{A,2}-\chi^u_{A,2}\right)+p_{F,2}\left(Y^u_{F,2}-\chi^u_{F,2}\right) &= 0 \end{aligned}$$

while the current account in the rest of the world is given by (27). Using the fact that the current account in upstream must be in balance in the current account of downstream, implies

$$p_{A,2}\left(Y^d_{A,2}+Y^u_{A,2}-\chi^d_{A,2}-\chi^u_{A,2}\right)+p_{F,2}\left(Y^d_{F,2}+Y^u_{F,2}-\chi^d_{F,2}-\chi^u_{F,2}\right)=0.$$

Therefore, (9) holds for $i \in \{w,d\}$. The prices of A-good and F-good are determined by productivity in downstream country and wages being equalized in both sectors in the rest of the world. This implies that the equilibrium prices between downstream country and the rest of the world are the same as in the free trade case, i.e. $p_{A,2} = p_{F,2} = \eta^{1-\alpha}$. Also the production of $\chi^d_{A,2}$, $\chi^d_{F,2}$ and Y^d_2 is the same. It is easy to show that, similarly to the case with fixed fees, the share of labor force working in A- and F-sector changes in the rest of the world, however it leaves Y^w_2 and C^w unchanged[15].

In upstream country, (16) gives

$$\frac{1-\tau_A}{1+\tau_F} = \frac{\gamma}{1-\gamma}\left(\frac{Y^u_{A,2}}{Y^u_{F,2}}\right)^{-\frac{1}{\epsilon}} \tag{36}$$

and the price index (10) implies the following relationship between τ_A and τ_F

$$\gamma^{\epsilon}\left(1-\tau_A\right)^{1-\epsilon} + \left(1-\gamma\right)^{\epsilon}\left(1+\tau_F\right)^{1-\epsilon} = \eta^{(\epsilon-1)(1-\alpha)} = \gamma^{\epsilon} + \left(1-\gamma\right)^{\epsilon}. \tag{37}$$

Upstream country trades only if it invests in technology and specializes in production of A-good, i.e. $l^u_{A,2} = 1$. In such case, (using (13) and (14)) production of A-good and F-good in upstream is

$$\chi^u_{A,2} = \alpha^{\frac{\alpha}{1-\alpha}}\left(1-\tau_A\right)^{\frac{\alpha}{1-\alpha}}\eta^{\alpha}\bar{A};\ \chi^u_{F,2} = 0 \tag{38}$$

This requires that $w_{A,2} > w_{F,2}$ and (using (17))defines the maximum for fees τ^m_A and τ^m_F that can be charged before upstream switches to autarky as

$$\frac{1-\tau^m_A}{1+\tau^m_F} = \frac{1}{\bar{A}^{1-\alpha}}. \tag{39}$$

Using (37), τ^m_F is determined by τ^m_A and maximum fees satisfy

$$\tau^m_A = 1 - \left(\frac{\bar{A}^{(1-\alpha)(\epsilon-1)}\gamma^{\epsilon} + (1-\gamma^{\epsilon})}{\bar{A}^{(1-\alpha)(\epsilon-1)}}\right)^{\frac{1}{\epsilon-1}} = 1 - \left(\frac{\hat{A}_{\Theta}}{\bar{A}}\right)^{1-\alpha}.$$

It is clear that $0 < \tau^m_A < 1$, the maximum fee is increasing in the quality of technology, $\bar{A}$ and $\lim\limits_{\bar{A}\to\infty} \tau^m_A = 1$.

From the current account in upstream country, (36), (38) and (37), we can find the usage of A-good and F-good and final good production as

$$\begin{aligned} Y^u_{A,2} &= \gamma^{\epsilon}\alpha^{\frac{\alpha}{1-\alpha}}\eta^{1-\epsilon(1-\alpha)}\bar{A}\left(1-\tau_A\right)^{-\epsilon}\left(1-\tau_A\right)^{\frac{1}{1-\alpha}} \\ Y^u_{F,2} &= \left(1-\gamma\right)^{\epsilon}\alpha^{\frac{\alpha}{1-\alpha}}\eta^{1-\epsilon(1-\alpha)}\bar{A}\left(1+\tau_F\right)^{-\epsilon}\left(1-\tau_A\right)^{\frac{1}{1-\alpha}} \\ Y^u_t &= \alpha^{\frac{\alpha}{1-\alpha}}\eta\bar{A}\left(1-\tau_A\right)^{\frac{1}{1-\alpha}}. \end{aligned} \tag{40}$$

[15] After solving for the equilibrium production and usage of A-good and F-good in upstream country, it can be shown that $l^w_{A,2} = \frac{\gamma^{\epsilon}L^w - \bar{A}(1-\gamma^{\epsilon})\left(1+(1-\tau_A)^{\frac{\alpha}{1-\alpha}}\right)}{L^w}$, which implies the same $Y^w_{A,2}$, $Y^w_{F,2}$ and Y^w_2 as in free trade.

The revenue of downstream country's from fees is $T^d = p_{A,2}\tau_A\left(\chi^u_{A,2} - Y^u_{A,2}\right) + p_{F,2}\tau_F Y^u_{F,2}$. Using (37), (38) and (40), this can be expressed as

$$T^d = \eta\bar{A}\alpha^{\frac{\alpha}{1-\alpha}}\frac{(1-\gamma)^{\epsilon}(1-\tau_A)^{\frac{\alpha}{1-\alpha}}(\tau_A + \tau_F[\tau_A])(1+\tau_F[\tau_A])^{-\epsilon}}{\gamma^{\epsilon} + (1-\gamma)^{\epsilon}}, \qquad (41)$$

where $\tau_F[\tau_A]$ denotes that τ_F is a function of τ_A according to (37). As the production and wages in downstream do not depend on the fees, the government maximizes the tax revenue, i.e.

$$\begin{aligned}\tau^{var}_A &= \max[\tau^*_A, \tau^m_A], \text{ where}\\ \tau^*_A &= \arg\max\left[T^d\right].\end{aligned}$$

As (41) is too complicated to give an explicit solution for τ^*_A, we can evaluate it it with a (second order) Taylor approximation around $\tau^*_A = 0$ as

$$T^d \approx \eta\bar{A}\alpha^{\frac{\alpha}{1-\alpha}}\left(\tau_A - \tau^2_A\frac{2\alpha(1-\gamma)^{\epsilon} + \gamma^{\epsilon}\epsilon(1-\alpha)}{(1-\gamma)^{\epsilon}(1-\alpha)}\right)$$

From here

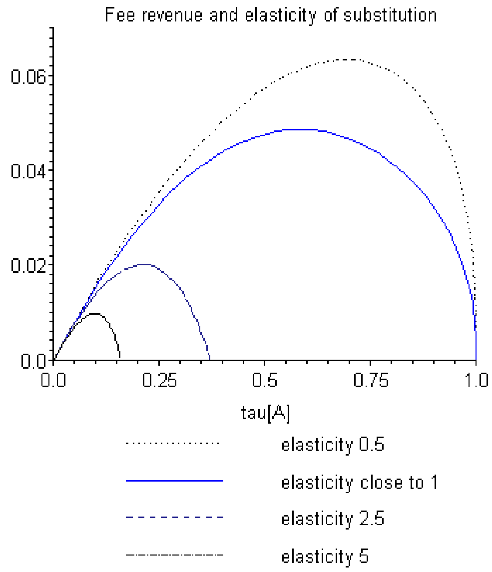
$$\tau^*_A = \frac{(1-\alpha)}{2\left(2\alpha + \epsilon(1-\alpha)\frac{\gamma^{\epsilon}}{(1-\gamma)^{\epsilon}}\right)}. \qquad (42)$$

And downstream country's income from fees is

$$T^{d*} = \begin{cases} \Gamma\eta\bar{A}\frac{1}{4}\left(2\alpha + \epsilon(1-\alpha)\frac{\gamma^{\epsilon}}{(1-\gamma)^{\epsilon}}\right)^{-1} & \text{if } \tau^*_A < \tau^m_A \\ \eta\bar{A}\alpha^{\frac{\alpha}{1-\alpha}}\frac{(1-\gamma)^{\epsilon}\left(\bar{A}^{1-\alpha} - \hat{A}^{1-\alpha}_{\Theta}\right)^{\alpha-(\epsilon-1)(1-\alpha)}\bar{A}^{\epsilon(1-\alpha)-\alpha}}{\gamma^{\epsilon}+(1-\gamma)^{\epsilon}} & \text{if } \tau^*_A \geq \tau^m_A \end{cases} \qquad (43)$$

The optimal fee, τ^*_A, does not depend on the quality of technology. Therefore, if $\bar{A}$ is not too low, $\tau^*_A < \tau^m_A$ and the production of final good is higher than in autarky. Furthermore, (first order) approximating τ^m_A around $\bar{A} = 1$, gives $\tau^m_A \approx (1-\alpha)\bar{A}$, which implies that $\tau^*_A < \tau^m_A$ if $\bar{A} > \frac{1}{4}\left(2\alpha + \epsilon(1-\alpha)\frac{\gamma^{\epsilon}}{(1-\gamma)^{\epsilon}}\right)^{-1}$ and is more likely if ϵ is high. It is never the case if the goods are perfect complements. In what follows assume that $\epsilon > 0$ and $\bar{A}$ is sufficiently high such that $\tau^*_A < \tau^m_A$.

The optimal tax rate depends negatively on the elasticity of substitution, ϵ. If the goods are perfect substitutes $\epsilon \to \infty$, the optimal tax rate becomes zero. This is intuitive, because high substitutability between goods reduces the gains from trade and upstream country can use only A-good for production of its consumption good. While if the goods are complements trade volumes are higher Figure ??? shows how fee revenues T^d depend on the



elasticity of substitution (optimal tax rate is numerically estimated from the original function instead of the approximation).[16]

The profit of technology sector in upstream country is given by

$$\pi^u_{A,2,var} = \alpha\Gamma\eta \left(1 - \tau^*_A\right)^{\frac{1}{1-\alpha}} \bar{A} \tag{44}$$

and the threshold for technology investment being undertaken is

$$I_{var} = \alpha\Gamma\eta \left(1 - \tau^*_A\right)^{\frac{1}{1-\alpha}} \bar{A} - \alpha\Gamma\eta. \tag{45}$$

This is lower than in free trade, however as by (39) $\left(1 - \tau^m_A\right)^{\frac{1}{1-\alpha}} \bar{A} = \left(1 + \tau^m_F\right)^{\frac{1}{1-\alpha}}$, the threshold is never lower than in autarky.

As long $I < I_{var}$, upstream country cannot lose from openness to trade and consumption in upstream country are not made and there is no reason for the government to decide not to be open to trade. $I < I_{var}$, consumption in upstream country

$$C^u_{var} = \Gamma\left(\eta + \eta \left(1 - \tau^*_A\right)^{\frac{1}{1-\alpha}} \bar{A} + 2\alpha\eta\right) + I_{var} - I.$$

and in downstream

$$C^d_{var} = T^{d*} + \Gamma\left(\eta + \eta\bar{A} + 2\alpha\eta\right) + \left(I^T - I\right). \tag{46}$$

[16]The values assumed are $\gamma = 0.5$, $\bar{A} = 1.1$ and $\alpha = 0.3$.

Consumption in upstream is the same of higher than in autarky and lower than in downstream country.

Finally, notice that if $I_{var} < I < I^T$, the upstream country does not in invest in technology and downstream country would not obtain the fee income. In such case, downstream country would like to commit to a tax rate $\tau_A^I < \tau_A^*$ that would make it just optimal for upstream country to invest in technology. Namely, from threshold (45) $\tau_A^I = 1 - \left(\frac{I+\alpha\Gamma\eta}{\alpha\Gamma\eta\bar{A}}\right)^{1-\alpha}$ and consumption in upstream and downstream country is

$$
\begin{aligned}
C^u_{var\_c} &= \Gamma\left(2\eta + 2\alpha\eta + \frac{I}{\Gamma\alpha}\right) \\
C^d_{var\_c} &= \Gamma\left(T^d\left(\tau_A^I\right) + \eta + \eta\bar{A} + 2\alpha\eta\right) + \left(I^T - I\right)
\end{aligned}
$$

As $T^d\left(\tau_A^I\right) < T^d\left(\tau_A^*\right)$ there is clear time inconsistence and downstream country would renegotiate the fees after investments have been made. When the fees are renegotiated, consumers in upstream country are worse off if $C^u_{var} < \Gamma\left(2\eta + 2\alpha\eta\right)$, i.e. if entrepreneurs in downstream country falsely believe in the commitment and

$$
I > \Gamma\eta\left(\left(1-\tau_A^*\right)^{\frac{1}{1-\alpha}}\bar{A} - 1\right) + I_{var}.
$$

This is similar to the results in the case of fixed fees (although it requires a "mistake" of local entrepreneurs)

2.4.3 Foreign ownership of technology firms

So far, it was assumed that the firms investing in technology are owned by local agents in each country. We now consider the impact of foreign ownership of equity in technology sector. We will consider two situations. First, the firms can be bought in period 1 after investment in technology has been made and before trade negotiations start (foreign takeover investments). Second, a foreign agent subsidize investment in technology in another country, without bringing the knowledge, which still requires the skills on a local entrepreneur foreign investment in technology. The latter assumption is to exclude the possibility of the rest of the world gaining access to better quality in A-sector, which would eliminate the gains from trade.

Foreign takeover investment

In most of the settings analyzed (autarky, free trade and fixed fees), the profit of firms in technology sector does not depend on the trade negotiations. As there is no uncertainty the price of firms always equals to the profit of the monopolistic firm in these cases, e.g. in the case of free trade $P_\pi^u = P_\pi^d = \alpha\Gamma\eta\bar{A}$ and $P_\pi^w = \alpha\eta\Gamma$. Therefore, the ownership of the firms does not have any impact on the equilibrium outcomes.

The situation is different in the case of firms in upstream country, when downstream country charger variable fees on goods passing through the country. As shown in Section ???, the profit of these firms in upstream country depends on the fees. If a local agent (or a rest of the world agent) owns the firm, the profit is given by (44) and is therefore also the minimum price entrepreneurs in this country willing to sell the firm for. However, if investor from downstream country owns the firm, it will potentially influence the downstream government to charge different fees. The profit of an upstream firm owned by a downstream investor is

$$\pi_{A,2}^{ud} = \alpha\Gamma\eta\left(1-\tau_A\right)^{\frac{1}{1-\alpha}}\bar{A}. \tag{47}$$

If $\tau_A > \tau_A^*$, the price of equity must be in between $\pi_{A,2}^{ud}$ and $\pi_{A,2,var}^{u}$ these two values. Let β be a measure of competition among investors from downstream country in the case of takeover ($\beta = 1$ indicates that no competition and just on potential buyer for upstream country) The equity price is

$$P_\pi^u = \beta\alpha\Gamma\eta\left(1-\tau_A^*\right)^{\frac{1}{1-\alpha}}\bar{A} + (1-\beta)\alpha\Gamma\eta\left(1-\tau_A\right)^{\frac{1}{1-\alpha}}\bar{A}. \tag{48}$$

Only the residents of downstream country are willing to pay this price as it is too high for local and the rest of the world investors. Consumption in downstream country is now given by

$$C^d = w_1^d + w_2^d L^d + \pi_{A,1}^d + \pi_{A,2}^d + T^d + \alpha\Gamma\eta\left(1-\tau_A\right)^{\frac{1}{1-\alpha}}\bar{A} - P_\pi^u - I.$$

As trade negotiations are held after the takeover, the downstream government takes price P_π^u as given and solves

$$\tau_A^{ft} = \arg\max\left(T^d + \alpha\Gamma\eta\left(1-\tau_A\right)^{\frac{1}{1-\alpha}}\bar{A}\right)$$

Approximating the objective of downstream countries' government around $\tau_A = 0$ as in previous section gives

$$\begin{aligned}&T^d + \alpha\Gamma\eta\left(1-\tau_A\right)^{\frac{1}{1-\alpha}}\bar{A} \approx \alpha\Gamma\eta\bar{A}\\ &\eta\bar{A}\alpha^{\frac{\alpha}{1-\alpha}}\left(\tau_A\left(1-\alpha\right) - \tau_A^2\frac{2\alpha\left(1-\gamma\right)^{\epsilon} + \gamma^{\epsilon}\epsilon\left(1-\alpha\right)}{\left(1-\gamma\right)^{\epsilon}\left(1-\alpha\right)} + \tau_A^2\frac{\alpha^2}{\left(1-\alpha\right)}\right) + .\end{aligned}$$

and the optimal fee is

$$\tau_A^{ft} = \frac{\left(1-\alpha\right)^2}{2\left(\alpha\left(2-\alpha\right) + \epsilon\left(1-\alpha\right)\frac{\gamma^{\epsilon}}{\left(1-\gamma\right)^{\epsilon}}\right)}.$$

It is clear that the optimal fee is smaller $\tau_A^{ft} < \tau_A^*$, because the government in upstream country takes into account the business interests of its residents in upstream country leading to more favorable trade conditions for upstream country.

If there is at least some competition among investors from downstream country in takeover, i.e. $\beta < 1$, the gains from investment in technology increase. Investment pays off if $P_\pi^u - \alpha\Gamma\eta > I$, which gives a threshold

$$\begin{aligned} I_{var\_ft} &= \beta\alpha\Gamma\eta\left(1-\tau_A^*\right)^{\frac{1}{1-\alpha}}\bar{A} + (1-\beta)\alpha\Gamma\eta\left(1-\tau_A\right)^{\frac{1}{1-\alpha}}\bar{A} - \alpha\Gamma\eta = \\ &= I_{var} + (1-\beta)\alpha\Gamma\eta\bar{A}\left[\left(1-\tau_A\right)^{\frac{1}{1-\alpha}} - \left(1-\tau_A^*\right)^{\frac{1}{1-\alpha}}\bar{A}\right] \end{aligned}$$

that is higher than in the case firms remain domestically owned.

The consumption in upstream country is given by

$$C_{ft}^u = \Gamma\left(\eta + \eta\left(1-\tau_A^{ft}\right)^{\frac{1}{1-\alpha}}\bar{A} + 2\alpha\eta\right) + I_{var\_ft} - I$$

and the country clearly gains from the downstream country's investors takeover of their firms in terms of wages (for any value of β) and in terms of profitability (and probability) of investment in technology (if $\beta > 0$).

In downstream country the income from fees only is

$$\begin{aligned} T^{d,ft} &\approx \eta\bar{A}\alpha^{\frac{\alpha}{1-\alpha}}\left(\tau_A^{ft} - \tau_A^{ft\,2}\frac{2\alpha+\frac{\gamma^\epsilon}{1-\gamma}\epsilon(1-\alpha)}{(1-\alpha)}\right) = \\ &= \Gamma\eta\bar{A}\frac{(1-\alpha)\left(2\alpha(1-2\alpha)+\epsilon(1-\alpha)^2\frac{\gamma^\epsilon}{(1-\gamma)^\epsilon}\right)}{4\left(\alpha(2-\alpha)+\epsilon(1-\alpha)\frac{\gamma^\epsilon}{(1-\gamma)^\epsilon}\right)^2} \end{aligned} \tag{49}$$

and is lower than in the case where upstream country's technology sector is owned by local agents there.

Consumption in downstream country is

$$C_{ft}^d = T^{d,ft} + \Gamma\left(\eta + \eta\bar{A} + 2\alpha\eta\right) + \left(\pi_{A,2}^{ud} - P_\pi^u\right) + \left(I^T - I\right).$$

and is higher than C_{ft}^d if $T^{d,ft} + \pi_{A,2}^{ud} - P_\pi^u > T^{d*}$. This in turn depends on the value of β. If $\beta = 1$, downstream investors earn excess profits, which offsets the lower fee revenue. If $\beta = 0$, $\pi_{A,2}^{ud} = P_\pi^u$ and there is no excess revenue implying that the consumption is lower.

There exists a threshold $\beta_{ft} \in (0,1)$ such that $C_{ft}^d = C_{var}^d$

$$\beta_{ft} = \frac{T^{d*} - T^{d,ft}}{\alpha\Gamma\eta\bar{A}\left[\left(1-\tau_A^{ft}\right)^{\frac{1}{1-\alpha}} - \left(1-\tau_A^{*ft}\right)^{\frac{1}{1-\alpha}}\right]}$$

Given this potential loss, the downstream government may want to restrict their agents' investment in equity in downstream country. This could be done by imposing a tax,λ, on profit earned from a foreign firm and distributing at as lump sum transfers $T^{\lambda} = \lambda \pi^{ud}_{A,2}$. Such tax affects the price downstream country's investors are willing to pay for a foreign asset. The price of a technology firm in such case is

$$P^u_\pi = \beta \alpha \Gamma \eta \left(1 - \tau^*_A\right)^{\frac{1}{1-\alpha}} \bar{A} + (1 - \lambda) (1 - \beta) \alpha \Gamma \eta \left(1 - \tau_A\right)^{\frac{1}{1-\alpha}} \bar{A}.$$

and it is clear that setting $\lambda \geq \beta_{ft}$ guarantees that the downstream country gains from its agents taking over the firms in upstream country.

There is an increase of value of technology sector firms in upstream country that are taken over by investors from downstream country that arises purely from the fact that such investors can lobby for more favorable trade conditions with upstream country.

Foreign greenfield investment

For simplicity consider a case that there is only one potential agent in downstream country willing to invest or take over firms in upstream country, such that $\beta = 1$. This implies that the price of an existing firm equals to profits of the firm in the ownership of a local agent $P^u_\pi = \pi^u_{A,2,var} = \alpha \Gamma \left(1 - \tau^*_A\right)^{\frac{1}{1-\alpha}} \bar{A}$.

If taxes are $\tau_A = \tau^{ft}_A < \tau^*_A$ the the threshold where investment in technology pays off falls. Namely,

$$I_f = \alpha \Gamma \eta \left(1 - \tau^{ft}_A\right)^{\frac{1}{1-\alpha}} \bar{A} - \alpha \Gamma \eta < I_{var}$$

In the range $I_{var} < I < I_f$, investment in technology in upstream country can be only made by an investor from downstream country.

Consider a joint venture between a local engineer and a downstream country's investor. Assume that there are no agency problems between the engineer/monopolist in upstream country. When $I > I_{var}$, the outside value of the engineer is no investment which gives $\alpha \Gamma \eta$. As downstream investor has bargaining power, it makes the engineer's participation constrain binding and engineer gets the outside value, while the downstream investor gets all the surplus, $I_f - I$.

From here consumption in downstream country is

$$C^d_{fg} = T^{d,ft} + \Gamma \left(\eta + \eta \bar{A} + 2\alpha\eta\right) + (I_f - I) + \left(I^T - I\right)$$

and in upstream country is

$$C^u_{fg} = \Gamma \left(\eta + \eta \left(1 - \tau^{ft}_A\right)^{\frac{1}{1-\alpha}} \bar{A} + 2\alpha\eta\right)$$

Both countries gain from the foreign investment as there would be no investment in technology in upstream country and no fee income for downstream country otherwise.

This benefit of foreign investments does not arise from any special skills of downstream country's investors, but purely from the opportunistic behavior of downstream country and the lobby of investors in downstream country.

When $I < I_{var}$, the engineer's outside option is $P^u_\pi - \alpha\Gamma\eta - I$ or $\pi^{ud}_{A,2} - \alpha\Gamma\eta - I$ depending on whether foreign takeovers are allowed (although as we show there is no reason for upstream country not to allow these in our setting) and there is no difference, whether investments in upstream country are made by local agents or in joint venture.

2.5 Summary of findings

The model suggests that while free-trade increases income and probability of investments in technology, a holdup problem, makes landlocked countries poorer and less likely to invest in technology. If trade agreements are renegotiable and investment in technology is relatively expensive, landlocked countries can be better off in autarky.This implies that these countries are less likely to be open to trade. When trading is optimal for landlocked countries, they are worse off if they specialize in goods that are not easily substitutable within the country as it increases the fee income transit countries can raise.

Finally, both foreign takovers and foreign investments in landlocked countries can arise purely from trade lobby.

3 Implications of the model and trade patterns.

The potential holdup problem faced by landlocked countries suggest that they trade less. To bring this prediction to trade data we also need to include exogenous transport costs which depend on distance. The transport costs would have a similar effect as the variable fees in our model, wiht the difference being that fees due to holdup are policy variables and they should not affect trade between countries that trade directly (e.g. neighbors or both not landlocked).

Introducing iceberg transportation costs (τ_T) in the model with variable fees, implies that a landlocked country receives $p_{A,2}(1-\tau_A)(1-\tau_T)$ for its exported good and pays $p_{F,2}(1+\tau_F(\tau_A))(1+\tau_{F,T}(\tau_T))$ for the good it imports, where $\tau_F(\tau_A)$ and $\tau_{F,T}(\tau_T)$ are increasing functions of τ_A and τ_T respectively. We can find imports (in the units of final good) from the current account as

$$Y^u_{F,2} - \chi^u_{F,2} = \frac{p_{A,2}}{p_{F,2}} \frac{(1-\tau_A)(1-\tau_T)}{(1+\tau_F(\tau_A))(1+\tau_{F,T}(\tau_T))} \left(\chi^u_{A,2} - Y^u_{A,2}\right).$$

It is easy to show that exports of the country is similar to (40).

$$\begin{aligned}
\chi^u_{A,2} &= \alpha^{\frac{\alpha}{1-\alpha}} \eta^{\alpha} \bar{A} (1-\tau_A)^{\frac{\alpha}{1-\alpha}} (1-\tau_T)^{\frac{\alpha}{1-\alpha}} \\
Y^u_{A,2} &= \gamma^{\epsilon} \alpha^{\frac{\alpha}{1-\alpha}} \eta^{1-\epsilon(1-\alpha)} \bar{A} (1-\tau_A)^{\frac{1}{1-\alpha}} (1-\tau_T)^{\frac{1}{1-\alpha}} (1+\tau_F(\tau_A))^{-\epsilon} (1+\tau_{F,T}(\tau_T))^{-\epsilon}
\end{aligned}$$

Using also the definition of η, $p_{F,2} = p_{A,2} = \eta^{1-\alpha}$ and that the price index implies $\gamma^{\epsilon}(1-\tau_A)^{1-\epsilon}(1-\tau_T)^{1-\epsilon} + (1-\gamma)^{\epsilon}(1+\tau_F)^{1-\epsilon}(1+\tau_{F,T}(\tau_T))^{1-\epsilon} = \eta^{(\epsilon-1)(1-\alpha)}$, we get that import

$$Y^u_{F,2} - \chi^u_{F,2} = \alpha^{\frac{\alpha}{1-\alpha}} \eta (1-\gamma)^{\epsilon} \bar{A} \frac{(1-\tau_A)^{\frac{1}{1-\alpha}}}{(1+\tau_F(\tau_A))^{\epsilon}} \frac{(1-\tau_T)^{\frac{1}{1-\alpha}}}{(1+\tau_{F,T}(\tau_T))^{\epsilon}}$$

is a decreasing function of both holdup fees and transportation costs as well as the characteristics of trading partners (through $\bar{A}, \gamma$ and η). We test three implications of the model.

The effect of potential for holdup on trade

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

$$\ln(imp)_{i,j,t} = \alpha X_{i,j,t} + \beta \tilde{\tau}_{T,t} + \gamma HU_{ij}, \tag{50}$$

where $X_{i,jt}$ represents country characteristics of trading partners, $\tilde{\tau}_{T,t}$.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 solve the holdup problem?

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

$$\ln(imp)_{i,j,t} = \alpha X_{i,j,t} + \beta\tilde{\tau}_{T,t} + \gamma HU_{ij} + \delta HU_{ij} \cdot TA_{ijkt}, \quad (51)$$

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 solve the holdup problem?

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

$$\ln(imp)_{i,j,t} = \alpha X_{i,j,t} + \beta\tilde{\tau}_{T,t} + \gamma_i HU_i + \gamma_j HU_j + \gamma_{F,j} HU_j \cdot FDI\_liab_j + \delta_j FDI\_liab_j, \quad (52)$$

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 liabilites 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 use an unbalanced panel of imports of 172 countries measured at 5 year intervals between 1950 and 2000 that is used by Subramanian and Wei (2007), which in turn builds on Rose (2004).[17] 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

[17] We use a different distance measure than Subramanian and Wei in most specifications. This distance measure builds on the gravity data assembled by CEPII and the country selection is somewhat different from Subramanian and Wei. For a full description of the data see the Appendix.

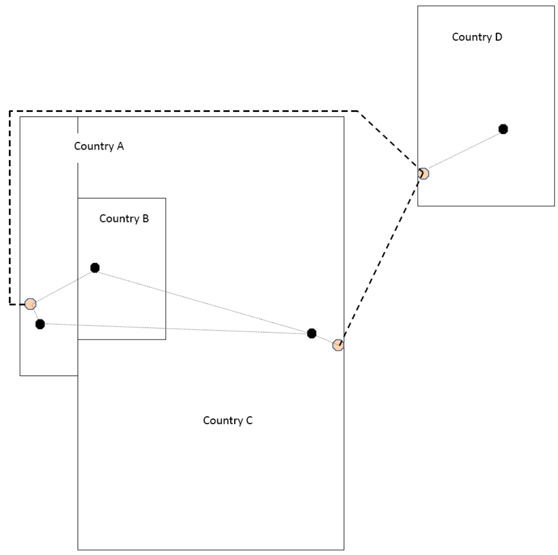
US 1982-83 dollars. All these variables are defined as in Subramanian and Wei (2007). In some specifications we use foreign direct investment liabilities as an explanatory variable, these are from Lane and Milesi-Ferretti (2007). The main differs from Subramian and Wei (2007) is distance - which we turn to now.

3.1.1 Measuring distance.

The literature that estimates gravity equations of trade has typically relied on distance measured as the great circle distance, either between main cities, a calculated population centre or the geographical midpoint of 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 neigbours, the distance of a landlocked country to trading partners is greater than that of its transit country - something we would not capture with great circle distances. As discussed below trade goods are typically shipped by sea, apart from trade with neighboring countries which goes overland. We use Figure **??** to illustrate the implication of this for distance and trade of landlocked countries. 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 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.[18]

Measuring distance via the closest ports rather than as great circle distance would potentially be 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 sharing a land border we therfore use great circle distances between main cities For nonad-

[18]Note that the estimated coefficient on distance in gravity models reflects more than just shipment costs (for instance a greater substitutability between home and foreign goods will decrease trade and thus appear as a greater effect of distance on trade flows, see Anderson and van Wincoop (2004) for an overview of the literature on trade costs). This does not make a measurement of the correct distance any less important.



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

jacent 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.[19] 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 transpport 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. Distnace 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.

In Table 1 we report the correlation between bilateral distances measured between main cities via the closest port, great circle distances between main

[19] Indeed the concept of "iceberg" transport costs, which is standard in the gravity litterature, conjures images of sea rather than air transport.

Table 1. Correlations between different measures of distance.

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).

cities and great circle distances between midpoints (distances measured in km using one observation for each potential trading pair). We do this separately for the cases where there is a potential holdup problem and where there is not. 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). As suggested by Figure 1 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[20] This is an indication that the mismeasurement issue discussed above may affect the interprestation 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 below we report the results from estimating eq (50). 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

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

between country midpoints. We use a slightly different set of covariates than Subramanian and Wei (for instance our holdup dummy and the number of islands in 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 is the same specification but with great circle distances between main cities and column 3 reports the regression with distance measured as distance via closest ports.Our main interest is on the coefficient on the holdup dummy and we now focus our discussion on this coefficient across the specifications. Using the estimate in column (3) the coefficient on holdup indicates that imports of a country from a parter 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 ovder 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 corresponding regression for the period 1990 and after - the coefficient on holdup is still significant and of similar magnitude however. 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 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 are much less severe in Europe, where in particular the European Union and later EU should imply an important restriction on the possibility of ex post opportunistic behavior on the part of 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. Our interest in in the share of land in transport with countries that are not adjacent and the measure is 0 for bordering countries - the effect of borders on trade is instead picked up by the border dummy. The lack of significance of the share of land transport surprised us - note though that for most trading relations this share is low and the exporter and importer fixed effects will also be picking up much of the variation in the share of land in distance. Also a closer look reveals that this variable is not the only high for the cases where there are really long overland stretches (say trade between the Kyrgyz Republic and its trading partners) but also for trading partners with main cities that are inland and that are closely located (such as Iran and Saudi Arabia). We would thus not draw the conclusion that trading costs over land are not higher than over sea, as shown in for instance Venables and Limão (2001) trading costs overland are indeed higher. We simply note that in a gravity regression, with this way of specifying the land share and these covariates, there is no systematic evidence that the land share has a robust relation to import volumes. We have experimented with different specifications for the land share, overall the impact on the holdup dummy is small. 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 in this specification 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 and common colonizer) 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 estimated strength of our coefficient of interest - the hold up 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 for instance Rose (2004), we therefore do not use time varying fixed effects and instead use time effects together with the products of gdp's and gdp's per capita of the importing and exporting countries in columns (1)-(6). For comparison 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 which implies that trade is about 36 percent lower if bilateral trade is subject to a potential holdup problem as defined in this paper. Column (2) reports the results from an estimation of eq. (51). There is no statistically significant effect of trade agreements with transit countries on trade flows. If we only examine the period after 1990 the point estimate is still low and not significant.[21] There is thus lit-

[21]Note that the set of landlocked countries is expanded in the later years when the

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

Variables	(1) limport	(2) limport	(3) limport	(4) limport	(5) limport	(6) limport
Distance measure	Great circle, midpoint	Great 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***	-0.781***
	(0.0233)	(0.0242)	(0.0340)	(0.0401)	(0.104)	(0.0639)
Share of land in distance			0.00754	-0.449	0.672	-1.333**
			(0.403)	(0.418)	(0.674)	(0.651)
Holdup	-0.494***	-0.585***	-0.512***	-0.594***	-0.518***	0.0134
	(0.0995)	(0.0953)	(0.104)	(0.110)	(0.155)	(0.0989)
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	African exports only	European exports only
Observations	71614	71614	71614	30435	15426	21748
Root MSE	1.656	1.659	1.666	1.761	1.942	1.123
Adjusted R-squared	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, ** significant at 5 percent and * significant at 10 percent.

tle indication that trade agreements with transit countries are effective in solving the holdup problem, even though we note that there is no evidence of the holdup problem when we examine European exports only (column 6 in Table 2). We may note that many of the African landlocked countries, and their transit countries, became members of GATT already in 1963. Other landlocked countries are late joiners to WTO/GATT. Latin America's two landlocked countries joined WTO/GATT in 1990 (Bolivia) and 1994 (Paraguay), in comparison with their coastal neighbours (Argentina,1967; Brazil,1948; Chile,1949; Uruguay,1953). The landlocked countries in Asia are also late joiners (Mongolia 1997; Nepal,2004; Afghanistan, Bhutan and Laos are among the few countries that are not yet members). In a setting with the weak institutional setting that plague many African countries it perhaps not surprising that trade agreements of the standard form have not been an effective remedy against fears of ex post opportunistic behavior.

Our model predicts that ownership by the transit country is a a way to solve the holdup problem. It is difficult to find reliable data on bilateral foreign direct investment liabilities by country 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 liabilites per capita for the exporter which we interact with the holdup dummy as in eq (52)..As a benchmark column (4) examines the holdup dum-

Soviet Union dissolves.

mies for the exporter and importer separately for the set of trade relations where we have fdi/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/capita for the exporter and interact it with the holdup dummy. Higher levels of fdi/capita is associated with more trade for 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/capita (8.03) the positive effect of fdi/capita for a landlocked country is to increase trade by 11 percent (exp(.0128*8.03)-1). This is consistent with our prediction that foreign ownership limits the holdup problem. 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 previous dataset to consider all possible trading relations - many of those are 0. As a first step we therefore estimate the probability that two countries trade in a given year as a function of the same set of covariates as in our baseline specification, including time varying exporter and importer fixed effects. Column (7) reports the marginal effects from a probit regression where the dependent variable is 1 if two countries trade and 0 otherwise. Including the 0 trade flows roughly doubles the data set for every year and to limit the computational burden we focus on the period for 1990 to 2000 (as in column 4 in Table 2). 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 (7). 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 the 99th percentile (a landshare of 0.42) is associated with a 30 percent lower probability of a postive trade flow (-0.71*0.42).

As in Helpman, Melitz and Rubinstein (2008) 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. In their work they find that common language is an attractive candidate for such a variable and we follow their lead in this. Column (8) 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 (7).

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

Variables	(1) Ln(import)	(2) Ln(import)	(3) Ln(import)	(4) Ln(import)	(6) Ln(import)	(7) Import=1 Probit	(8) Ln(import) Heckman	(9) Ln(import) 100 bins (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 land in distance	0.604*	0.602*	0.0334	-0.503	-0.484	-0.712***	-0.388	0.109
	(0.320)	(0.320)	(0.374)	(0.384)	(0.384)	(0.140)	(0.416)	(0.394)
Holdup	-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)
Holdup*fta		0.0436	0.0543					
		(0.0512)	(0.0599)					
HUI (Holdup Import)				-0.205***	-0.299***			
				(0.0513)	(0.0552)			
HUE (Holdup Export)				-0.395***	-0.374***			
				(0.0549)	(0.0549)			
HUE*FDI/CAP					0.0128**			
					(0.00620)			
FDI/CAP					0.0351***			
					(0.00233)			
Common language	0.332***	0.332***	0.493***	0.539***	0.543***	0.118***		
	(0.0431)	(0.0431)	(0.0514)	(0.0570)	(0.0537)	(0.0122)		
Inverse Mills ratio							0.0246	
							(0.225)	
Sample	Full	Full	1990-2000	1995-2000	1995-2000	1990-2000	1990-2000	1990-2000
Observations	69481	69481	28302	18347	18347	54098	29905	29905
Adjusted R-squared	0.637	0.637	0.671	0.689	0.694	0.579 (pseudo R2)	0.731	0.741
Root MSE	1.943	1.943	2.026	1.908	1.890		1.786	1.755

Notes: Columns (1-6) include exporter, importer and year fixed effects. In addition all regressions include a constant and controls for product of gdp's and product of gdp's per capita, co
colonizer, former colonial relation, current colonial relation, currency union membership, free trade agreement, generalized system of preferences, number of islands in trading relation, c
Columns (7-9) include time varying exporter and importer fixed effects instead of time effects, the products of gdp's and of gdp's per capita. Column (7) reports marginal effects. Colum
predicted probabilities from (7) sorted into bins following Helman, Melitz and Rubinstein (2008). Distance measure is sea+land between main cities in all specifications. Standard errors
country pair. *** significant at 1 percent, ** significant at 5 percent and * significant at 10 percent.

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 probabilites from a first stage probit estimation (column 7) into a large number of 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 a trading relation results in a fall in the coefficients measuring trade frictions - a finding that can be interpreted as supporting the effect of unobserved heterogeneity at the firm level on trade. For our purposes we note that the holdup dummy, even though lower is still highly significant and in the same ballpark range.

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 to 80 percent (column 9, Table 3 and column 4 Table 2, respectively) in specifications where we include importer and exporter fixed effects. Notably, this effect is not a result of a potential underreporting 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 Russion gas flowing through Ukraine to 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

To be completed

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Appendix A

We explore the composition of exports using export data at the 4-digit level SITC Rev 2.[22] One possible classification is that proposed by OECD (1994) - they classify products as non-fuel primary commodites, resource intensive manufactures, labor intensive manufactures, differentiated products

[22] Data is for 2000 and is from NBER/UN as reported by Feenstra et al (2005). It builds on imports into 72 countries. Thus there is some underreporting of trade for some landlocked countries that are not present as importers in the data set. For instance the data set includes exports from Burkina Faso to Algeria or Angola (among the 72) but not Burkinian exports to Niger (not one of the 72). Since the importing countries in the data set account for 98 percent of world trade they are nevertheless likely to give a relevant picture of the composition of exports. The data covers the period 1962-2000 and for data before 1984 imports for all countries are reported. The pattern that emerges when we explore these data are similar as the one presented for 2000; for instance a close examination of trade for 1980 using the OECD classification yields the same significant differences as the ones reported in Table 2 (some minor misclassification may arise because these data are reported in SITC Rev 1). Some differences exist, for instance using the Rauch classification does not yield differences between landlocked and coastal. This is likely to be a reflection of the rapid development of many coastal economies between 1980 and 2000.

requiring specialized suppliers, scale-intensive manufactures or science based manufactures.

The upfront investment is likely to be much greater for the latter three types of products. We therefore examine the share of each category relative to total exports (in the categories classified by OECD, thus excluding for instance oil). Indeed a comparison of exports across coastal and landlocked countries confirms that, outside Europe, landlocked countries export primary commidities to a greater extent and to a lesser extent products requiring specialized suppliers, large scale or science. Another frequently used classification is into differentiated, exchange traded and reference priced products proposed by Rauch (1999). The sunk cost of producing may or may not be higher for differentiated products than for the other categories, but at least 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.

Even in the absence of holdup problems a landlocked country will face higher transport costs to overseas markets than a coastal economy. All else equal we would thus expect landlocked countries to have a lower share of exports in products that are heavy in relation to their value.[23] To explore this we construct the shares of exports for countries that fall into quartiles of 4-digit products defined by their weight/value ratio (we use the median weight to value ratio across all countries to define these).[24] We indeed see that on average a lower share of exports are in the type of products with the highest weight to value ratio for landlocked countries, both within and outside Europe. High transport costs make it less attractive for Austria and Switzerland to export bulky low value products as well. Finally the holdup problem present in our model implies that a landlocked country without stable access to the sea would be well advised to specialize in products with a very low weight in relation to their value, such that transport by air is a viable option. In some contradiction to this prediction we find no significant differences in the means for the share of exports that fall in the lowest weight

[23]Indeed, Harrigan (2005) finds some support for that U.S. imports from more distant countries have higher unit values and are more likely to be shipped by air.

[24]To indicate the type of products lowest weight to value ratio ranges from heavy aircraft (SITC 7924), medium heavy aircraft (7923) and reaction engines (7144) to fabrics woven of regenerated fibres (6538),special products of textile material (6579) and bovine leather (6114). The highest weight to value quartile ranges from polyethylene (5831), printing and writing paper (6412) and lubricating petroleum oils (3345) to crushed stone (2734), iron ore agglomerates (2816) and pebbles and roasted iron pyrites (2814).

Table A1. Classification of goods from OECD (1994)

Category	SITC Rev 2 codes
Non-fuel primary commodities	0, 1, 2 (less, 233, 244, 266, 267), 4, 68
Resource-intensive manufactures	
Woods products	63, 82
Non-metallic mineral products	66
Labor intensive manufactures	
Leather, textiles, apparel, footwear	61, 65, 83, 84, 85
Fabricated metal products	69
Other manufactures, excluding plastics	89 less 893
Differentiated products requiring specialized suppliers	
Non-electrical machinery	71, 72, 73, 74
Electrical machinery	77
Communications equipment	76
Scale-intensive manufactures	
Paper	64
Chemicals excluding pharmeceuticals	5 less 54
Rubber and plastic products	62, 893
Iron and steel	67
Road motor vehicles	781-784
Ships and other transport equipment other than aerospace	79 less 792
Science-based manufactures	
Aircraft	792
Computers and office equipment	75
Pharmaceuticals	54
Scientific instruments	87, 88

Table A2. Share of exports in 2000 according to various characteristics, coastal and landlocked countries.

	Coastal countries			*Landlocked countries*				
	Mean	*Std. err*	*Obs*	*Mean*	*Std. Err*	*Obs*	*Diff*	*t-s*
Share of exports that are (excluding Europe):								
Non-fuel primary commodities	49.28	3.07	104	71.46	5.18	24	-22.28	-3.
Resource intensive manufactures	6.89	1.25	96	7.61	4.45	18	-0.72	-0.
Labor intensive manufactures	19.93	2.32	103	17.15	4.91	21	2.78	0.5
Differentiated products requiring specialized suppliers	9.93	1.39	104	3.16	0.92	24	6.77	4.0
Scale-intensive manufactures	10.47	1.47	99	4.18	1.61	21	6.29	2.8
Science-based manufactures	4.92	0.73	100	1.14	0.36	21	3.77	4.5
Share of exports that are differentiated (Rauch):								
all countries	41.09	2.52	134	29.71	4.94	31	11.38	-0.
Europe only	57.78	3.84	30	62.21	6.59	7	-4.43	-0.
non-Europe	36.28	2.89	104	20.23	4.52	24	16.05	2.9
Africa	24.92	4.50	33	12.14	2.45	11	12.78	2.5
Share of export in highest weight/value quartile:								
all countries	36.48	2.63	133	24.94	4.55	31	11.54	2.2
Europe only	25.18	3.39	30	15.50	3.13	7	9.69	2.1
non-Europe	39.77	3.18	103	27.69	5.72	24	12.08	1.8
Africa	41.89	6.04	33	16.13	6.27	11	25.76	2.9
Share of export in lowest weight/value quartile:								
all countries	22.13	1.99	134	16.02	3.77	30	6.12	1.4
Europe only	27.11	2.69	30	23.09	4.04	7	4.02	0.8
non-Europe	20.70	2.44	104	13.86	4.70	23	6.83	1.2
Africa	10.08	3.01	33	5.06	1.54	10	5.02	1.4

This table presents two-sample t-test assuming unequal variances for the variables detailed in the left-most column. H0 is that means for landlocked and are the same, *** denotes that this can be rejected at 1% level, ** 5% and *10% level of confidence. Data for 2000 from NBER/UN as reported in Feens (2005). Weight to value ratio calculated at the SITC (rev 2) 4-digit level. Median weight to value ratios are calculated across all exporters and produ grouped into quartiles. Share of exports for each source country that falls into each weight to value quartile reported in last 8 rows. For the share of expo are differentiated we use the Rauch ("liberal" version) classification. Share of exports in different types of commodities following OECD (1994), see Tabl to value quartile. Note thought that succesul production of products with a low weight to value ratio is complex. Many of the products that have a low weigth to value ratio require investments that make them sensitive to holdup problems. Investment goods (defined as goods falling into any of the "specialized suppliers", "large scale" or "science".categories as defined by OECD) make up 80 percent of value of trade of the goods that fall into lightest weight to value quartile. For trade in the other weight to value categories investment goods make up 39 percent of value.[25]

At a very broad level the trade composition is thus consistent with the logic underlying our model - transport costs matter irrespective of institutional setting but for countries where one can argue that holdup problems are potentially more severe we see less exports of products that feature large sunk investment costs. The above evidence points to that the the main predictions of our model are consistent with oberved trade patterns. One way to try to test implications more sharply is to turn to regression analysis and control for other variables than whether a country is landlocked. Many facets of location, factor endowments and institutional environment lie behind the different composition of exports from Japan and the Central African Republic apart from their coastal status. As a step in that direction we regress the share of exports that are investment goods on gdp per capita (in levels and a quadratic term) and on a dummy for landlocked in columns (1)-(3) of Table 3. As suggested, outside Europe the share of investment goods in exports is lower for landlocked countries outside Europe. The negative relation between being landlocked and the share of investment goods also holds when we in column (4) use continental dummies rather than gdp per capita as controls. Our model suggested that foreign direct investments (fdi) would be a way of circumventing the holdup problem (going outside the model one can imagine that it is harder to holdup a European or US multinational than a local firm from Niger). Column (5) therefore includes a measure of fdi and of fdi interacted with being landlocked. Consistent with the model the interaction term is significant such that higher fdi per capita is associated with a higher share of investment goods in exports. Outside Europe the interaction term is not significant however. We view the regressions in Table 3 as a way to describe statistical relations and not reflecting causal relationships.

[25] These figures are calculated on the data that underlie Table 2. At an anecdotal level it is often mentioned that landlocked countries export raw materials with a low weight to value ratio (diamonds from Botswana) or illicit drugs with a low weight to value ratio (Afghanistan is the leading grower of opiates and until recently Laos was as well; Bolivia is a leading grower of coca; see UNODC (2007)). Including illicit drugs in the trade data is clearly associated with monumental measurement problems and we have not explored this further.

Table A3. The share of exports that are investment goods.

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	(6)
Landlocked	0.007 (0.040)	0.200 (0.065)***	-0.071 (0.034)**	-0.100 (0.039)**	-0.082 (0.042)*	-0.123 (0.054)**
Gdp per capita	0.040 (0.007)***	0.045 (0.010)***	0.025 (0.009)***			
Gdp per capita squared	-0.001 (0.000)***	-0.001 (0.000)***	-0.000 (0.000)			
continent=Africa				0.146 (0.031)***	0.118 (0.032)***	0.131 (0.033)***
continent=America				0.248 (0.042)***	0.241 (0.050)***	0.250 (0.051)***
continent=Asia				0.309 (0.043)***	0.289 (0.047)***	0.306 (0.048)***
continent=Europe				0.499 (0.040)***	0.437 (0.043)***	0.000 (0.000)
continent=Pacific				0.251 (0.093)***	0.069 (0.037)*	0.073 (0.039)*
Fdi liabilities per cap. (*1000)					0.009 (0.004)**	0.007 (0.004)*
Landl*Fdi liab. per cap (*1000)					0.024 (0.011)**	-0.046 (0.168)
Constant	0.126 (0.026)***	0.203 (0.060)***	0.141 (0.029)***			
Sample	All countries	Europe only	Non-Europe only	All countries	All countries	Non-Europe only
Observations	154	37	117	165	135	98
Adjusted R-squared	0.38	0.37	0.32	0.63	0.68	0.53
Root MSE	0.21	0.18	0.20	0.23	0.22	0.22

Dependent variable is the share of exports that are in ”Differentiated products requiring specialized suppliers”, ”scale-intensive manufactures” or ”science based manufactures” (based on categorization SITC rev 4 following OECD (1994). The categories that make up total exports in this calculation are those detailed in Table 2. Fuel exports are thus excluded from the total. Trade data for 2000 from NBER/UN as reported in Feenstra et al (2005). Gdp per capita from WDI and Fdi liabilities from Lane and Milesi-Ferreti (2006). All regressions estimated with OLS. Robust standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%