Technology, Networks and Trade

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PRELIMINARY AND INCOMPLETE

Abstract

We develop a general equilibrium model of strategic network formation in international trade, where firms choose specializations and trade links in a Ricardian setting. Countries sequentially open up to trade and strategic network formation leads to outcomes that are stable but potentially inefficient. In a benchmark fixed network, a competitive equilibrium is an Arrow-Debreu equilibrium, which critically hinges on costless pass-through trade. Equilibrium depends on the classical exogenous parameters of technology and labor endowments, and novel in this context, the network position of countries. For an endogenous network without fixed trade costs, an efficient network will arise, but dynamic externalities exist across countries not engaged in the link formation. We then characterize specialization patterns in equilibrium. We subsequently relax several assumptions of the model. First, incomplete pass-through in a fixed network potentially leads to the breakdown of trade as some countries can be better off in autarky. Pass-through will not arise in the endogenous network, even in the absence of trade costs. Second, variable costs of exporting affect the equilibrium quantities, but not the characterization of the network formation equilibria. Fixed costs of exporting exhibit hysteresis: starting from an empty network and uniformly lowering fixed costs can lead to different stable networks in contrast to starting from the free trade complete network and uniformly raising fixed costs. Third, if we allow for domestic transfers, price discrimination along different trade links is sustainable, even with perfect competition. Finally, to further discriminate against a typical trade model, we consider comparative statics that are unique to a network setting: (i) the entry of a new node to the network, and how this affects re-specialization patterns across the network and (ii) technology shocks and its propagation over the network.

1 Introduction

1.1 Motivation

The theory of international trade is traditionally focused around 2 central questions (Costinot and Donaldson, 2014):

1. How does the integration of good markets affect good prices?

2. How do changes in good prices in turn, affect factor prices, factor allocation, production and welfare?

In order to attack these questions, the literature has generally proposed different sources for trade, based on i) different technologies (Ricardo), ii) different factor endowments (Heckscher-Ohlin), iii) increasing returns to scale (Krugman 1979, 1980) and iv) heterogeneous firms (Melitz, 2003). We take a look at these questions from a networks perspective, in other words: “How does the structure of the world trade network (WTN) affect trading patterns and vice versa?”. ’Trading patterns’ in this setting include the set of factor prices, goods prices, factor allocation, production, trade and welfare. In particular, we are interested in the following additional questions:

*We would like to thank Matthew O. Jackson and Kyle Bagwell at the Stanford Dept. of Economics for many helpful comments and discussions while setting up this project. We also thank Leonie Baumann, Andreas Bjerre-Nielsen and Theodoros Rapanos and participants at the Networks Discussion Group at Stanford for fruitful discussions. Glenn Magerman gratefully acknowledges financial support from the Fulbright Foundation Belgium-Luxembourg, the Otlet-La Fontaine scholarship granted by Yves Moureau at the Department of Engineering at the University of Leuven, and the Junior Mobility grant by the University of Leuven. Part of this research is conducted while visiting the Stanford Dept. of Economics. KU Leuven - University of Leuven, Department of Business and Economics, Centre for Economic Studies, Naamsestraat 69, 3000 Leuven, Belgium, and Leuven Centre for Irish Studies, Janseniusstraat 1, 3000 Leuven, Belgium. E-mail: glenn.magerman@kuleuven.be.
1. Are the networks that arise from sequentially opening up stable and/or efficient?

2. How does network formation drive prices, quantities, specializations and welfare?

3. What kinds of network externalities arise?

4. What are potential policy implications: domestic transfers, trade policy, ...?

**Some theoretical motivations and stylized facts**

1. Key to our motivation is to consider the interdependencies between countries as they engage in trade and when exogenous shocks hit the system.

2. Models of international trade generally compare autarky equilibrium with free trade equilibrium in the long run. In reality the world trade network evolves over time: the average unweighted degree of the WTN (i.e. the number of trading partners) has increased from 90 to 119 over the time period 1998-2009 (De Bruyne, Magerman and Van Hove, 2013). Does the sequence of opening up matter for equilibrium and efficient outcomes?

3. Many different models of trade have sharp predictions of what the realized structure of the network is. Can we characterize the resulting networks by parameters from the original trade models? Do these trade models also allow for the core-periphery structure at the country level we observe in reality?

### 1.2 Network structure of standard trade models

In this section, we take a holistic view on how standard trade models predict realized network structures, which we can observe in the data.¹

- **Ricardian models** of perfect competition with variable trade costs in essence provide for “local stars”: each good is purchased from only one exporting country for a given importing country (Eaton and Kortum, 2002). In other words, a firm does not capture the world market for its good, but it is seen country by country, where it takes the whole market inside a country. In the EK model, all the action is on the extensive margin: firms compete heads-on for a set of homogeneous goods. In the Bernard, Eaton, Jensen and Kortum (2003) (henceforth BEJK) framework, Bertrand competition with different marginal costs exists, leading to heterogeneous markups, as leading firms can charge prices above marginal costs so to undercut the marginal cost of production of the second-best supplier. Some examples for \(N\) countries and 2 goods are given in figure 1: nodes at the top in each panel are specialized in cloth, nodes at the bottom are specialized in wine. Since goods are identical, nodes that produce the same commodity cannot exchange in trade. However, it is not immediately obvious how the equilibrium network looks like: in the EK model, the supplier inside a country is uniquely determined by productivity, trade costs and wages. However, in another country, another supplier might exist. Additionally, since there is a continuum of goods, trade in other goods might exist while countries specialize in sets of goods, rather than seeing complete specialization in 1 good. In the special case derived by Jones (1961), where there are \(I\) goods and \(I\) countries absent of trade costs, there will be a unique equilibrium with complete specialization in each country. Each country is then the “global star” for its good, supplied all over the world. This then leads to a complete network.

- **Models of monopolistic competition** with CES utilities predict complete networks (i.e. all the action is on the intensive margin). This is driven the self-selection into unique varieties by firms, and by love for variety as consumers prefer some of each unique variety. Adding iceberg trade costs does not alter the structure of the network: variable trade costs increase the marginal cost and reduce profits, but firms still find it optimal to export quantities to all countries, even with trade costs tending to infinity. This is the same for models with the Armington assumption and love for variety (e.g. Anderson and

¹It is interesting to note that competition structures can change drastically by adding or deleting just one link (see Easley and Kleinberg, 2011): a simple network structure can switch from monopoly to perfect competition by adding just one link. However the other way around, a realized network contains a lot of information regarding the underlying (and assumed) competition structure.
van Wincoop, 2003), where goods by definition are differentiated by origin. However, in reality many zero trade flows exist at the country level: in 2009, the undirected density\(^2\) of the world trade network at the country level is 0.65 (De Bruyne, Magerman and Van Hove, 2013).

- In models with **heterogenous firms** in a **monopolistic competition setting** with **CES preferences** and fixed costs of exporting (Melitz, 2003; Helpman, Melitz and Rubinstein, 2008; Chaney, 2008), zero trade flows arise through fixed costs. In models with CES preferences and monopolistic competition, this is the only way to generate selection into exporting (Manova, 2014). Again, it is not completely clear how the equilibrium network visualizes.

### 1.3 Related literature

This setup draws mainly from two literatures: that of international trade theory, and that of network theory. The broad categories of trade models where firm strategy is not explicitly modeled have been outlined above. There is of course a vast literature on industrial organization models in trade with imperfect competition on which we do not expand on here. A particular model of international trade which studies the effect of sequentially opening up to trade is that of Caroline Freund (2000). With three identical countries, \( n \) homogeneous goods and Cournot competition with sunk costs, Freund shows that sequentially opening up to trade can have different results from multilaterally opening up to trade, as changing the structure of production and trade can be costly. Goods flow disproportionately more between original members of a regional agreement, even after settling in free trade. Members get a higher welfare in regionalism than do non-members. Chaney (2014) puts the Jackson and Rogers (2007) model of hybrid network formation into a geographical context of trade. In the original Jackson and Rogers paper, agents choose a fraction of their friends through random encounters, and the other fraction through friends of friends. Firms are born every period and they link to existing firms. These firms can only trade over the network they posses. Where Chaney adapts the Jackson and Rogers hybrid network formation model of contacts to a trade setting, we consider a network formation game governed by technology differences and its efficiency implications. In particular, we look at the following research questions: i) is network formation efficient? ii) how does the network formation game drive prices, quantities, specializations and welfare? iii) what kinds of network externalities arise? iv) what is the role for policy?

In the literature on network theory, there is a broad class of models on trade in networks. These models consist of exogenously defined buyers and sellers, and possibly intermediaries. Buyers only have valuation for the good that is sold and sellers have only valuation for cash. The focus there is if trade takes place over the network, how agents can exploit their position in the network in terms of extracting surplus, and what kinds of structures of networks are efficient. Here, we expand on this by endogenizing the network and endogenizing buyers and sellers: choosing a specialization or particular diversification endogenizes what position an agent takes as a buyer or a seller in the network. Additionally, following the trade literature, consumers have identical demands across countries, where many trade-in-networks models assume only valuation of the good

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\(^2\)The undirected network density \( D \), is measured as the fraction of existing trade links \( E \) over the potential trade links over \( N \) nodes in the network: \( D = \frac{E}{N(N-1)} \).
that is not in possession. In this literature, two papers that focus on exchange economies are related to our setup. The first one (Kakade, Kearns and Ortiz, 2004) looks at different prices in networks in a "graphical" Arrow-Debreu setting. An endowment economy is set in a fixed network, and agents that are connected in the network can trade without trade costs. If no link exists, trade is impossible (embargo, ...). However, several differences exist with respect to the current setting: endowment economies and differences in preferences are needed to show different equilibrium 'local' prices. A follow-up by Even-Dar, Kearns and Suri (2007), models a network formation game for bipartite exchange economies. Agents can simultaneously pay a fixed cost for link formation, and then trade takes place over the resulting network. These authors are able to derive general characteristics over the network, something which is not possible yet in our setting. Close to our work is that of Furusawa and Konishi (2005), which look at the incentives of signing free trade agreements in a network formation game with \(n\) countries in a model of monopolistic competition. Their model is not based on a perfectly competitive Ricardian model of trade with different technologies and country sizes, but endowments in their setting are the number of firms in a country and the market size.

Finally, in our setup, firms make decisions, while the node-level is the country. If countries could coordinate internally on price discrimination, this would lead to possibilities to exploit network position. There is a literature on perfect competition with different prices, which might be tangent to our setup. Eden (1990) and Dana (1999) show how different prices can arise from demand uncertainty. More related to our setup is the class of models of dynamic Ricardian models: the key intuition there is that firms have to set prices before quantities are known in the world market. This can lead to dynamic price discrimination in the line of the tatonnement process in general equilibrium as first pointed out by Walras (1874).

Our contributions with respect to the existing literature are the following. First, we endogenize buyers and sellers in this setting. This extends the endowment economy setting by Kakade, Kearns and Ortiz (2004) to a production economy with transfers. Second, a particular empirical problem with trade models is that autarky is not observed, so it is difficult to compare autarky to integrated equilibrium (IE). However, allowing for sequentially opening up to trade, we can observe different snapshots of the network and infer changes in primitives of the model and how they relate to the network formation process. Finally, this project is also an exercise in how different trade models predict different network structures (stars, complete, core-periphery, ...) and how we can relate it to what we observe in reality.

1.4 Road map - the benchmark model

To fix ideas, we start with the simplest possible general equilibrium model of horizontal trade embedded in a network. Several assumptions are made to strip down the model so we can observe possible network externalities separately from other typical externalities that can arise in similar models. This baseline model has no strategic network formation involved, as prices, quantities and trade patterns all pop out from the general equilibrium setting. There is endogenous network formation however, and externalities arise, but no firm or country can strategically benefit from it. Therefore we will have to relax one or more assumptions to allow for strategy later on. However, it can serve as a good benchmark for comparing the relaxed outcomes.

- **Perfect competition**: goods produced in the same sectors are perfect substitutes (Ricardian model). The same goods taxed internationally enter competition heads-on and compete in prices.\(^3\)

- **Zero trade costs**: there are no variable trade costs (iceberg trade costs) nor fixed costs of exporting associated with trading over the network.\(^4\)

- **Complete passthrough**: since goods inside a sector are completely identical, the origin of the good doesn’t matter. If we look at a fixed network, a country might have to use imported goods from a first partner to re-export in order to induce trade with a second partner.

\(^{3}\)This is in contrast with other typical models of international trade where direct competition between identical goods is avoided, such as Armington-type models with CES preferences where goods are differentiated by country of origin by definition (Anderson and van Wincoop, 2003), and monopolistic competition models, where firms self-select into producing a unique variety (Eaton and Kortum, 2001). In Eaton and Kortum (2002), there is perfect competition across a continuum of goods, where identical goods do compete heads on. In Bernard, Eaton, Jensen and Kortum (2003), there is Bertrand competition with different marginal costs for identical goods, leading to heterogeneous markups.

\(^{4}\)Classical trade models with variable trade costs include Eaton and Kortum (2002), Anderson and van Wincoop (2003) and with fixed costs of exporting, as formalized by Melitz (2003).
• **No domestic transfers**: A country is not able to tax one good from one partner to equalize prices inside that country.

• **No trade policy**: countries cannot unilaterally or multilaterally set policies where coalitions can collude against outsiders.

2 The model and autarky equilibrium

For expositional purposes, we start with the case of 3 countries and 2 goods. We then generalize in both directions, more countries and more goods in an Eaton and Kortum (2002) framework [Not in this version, results available].

1. The network

Let \( i \in N = \{F, P, E\} \) represent a node in the network, a country in our case (for ease, the set consists of France, Portugal and England). Nodes \( i \) and \( j \) share a link \( ij \) if they can trade (in this case, if they can exchange goods). The network is undirected in the sense that goods are exchanged bilaterally for a given trade pair. For each link however, there is a set of equilibrium quantities attached to the trade link: \( \Delta = \{p, q, w, X, M, W\} \), where bold characters denote vectors, \( p \) denotes relative prices, \( q \) denotes production quantities, \( w \) denotes factor prices (wages), and \( X \) and \( M \) denote absolute exports and imports. \( W \) denotes the welfare of a country, measured in aggregate consumer utility. Let \( g \in G = \{N, g, \Delta\} \) be a realized network on the set of all possible networks \( G \). There is perfect information over the structure of the network and all quantities attached to it.

2. Supply

Each \( i \) is endowed with a country-specific technology, \( a^i_k \), for each good \( k \), and a labor force \( L^i \). The technologies express the unit labor requirement for each good. Each \( i \) can produce any combination of 2 goods \( k \in \{c, w\} \), cloth and wine, according to a linear production possibility frontier (PPF) given by the full employment condition:

\[
L^i = \sum_k a^i_k y_k(g) \tag{1}
\]

Note that the amount that is produced for each good inside a country will also depend on the network \( g \). There are many firms inside one country, which compete in prices. There is only one factor of production, labor, which is paid in wages \( w^i_k \). The factor is perfectly mobile across sectors inside a country, and perfectly immobile across countries. There is perfect competition, so price \( p^i_k \) equals marginal cost: \( p^i_k = a^i_k w^i_k \).

3. Demand

Demand is homothetic and identical across countries. Representative consumers maximize their Cobb-Douglas utility:

\[
U^i(x^i_c, x^i_w, g) = (x^i_c(g))^{\alpha} (x^i_w(g))^{\beta} \tag{2}
\]

subject to their budget constraint \( \sum_k p^i_k x^i_k(g) = w^i \). Relative demands are then given by \( \frac{x^i_c}{x^i_w} = \frac{\alpha p^i_c}{\beta p^i_w} \) and absolute demands: \( x_k = \left( \frac{\alpha}{\alpha + \beta} \right) \frac{w^i}{p^i_k} \).

4. Autarky equilibrium

Wages have to settle between sectors inside a country, so relative prices are given by relative productivities: \( \frac{p^i_c}{p^i_w} = a^i_c/a^i_w \). From now on, w.l.o.g., we set \( p \equiv p_c \). Equilibrium outputs in autarky are given by: \( L^i x^i_c = \left( \frac{\alpha}{\alpha + \beta} \right) \frac{L^i}{w^i_c} \) and similarly \( L^i x^i_w = \left( \frac{\beta}{\alpha + \beta} \right) \frac{L^i}{w^i_c} \). This characterizes all elements in the set \( \Delta \) in autarky.

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5 In most trade models, a CES function is assumed to allow for love of variety by the substitution parameter \( \rho \). We add the parameter in our model in the appendix, but this does not alter the nature of our qualitative results.
3. Frictionless trade equilibrium

In this game, firms simultaneously decide on link formation (who to trade with) and the amounts of each good to produce (specialization). From the general equilibrium setting, wages, prices and quantities will settle in equilibrium.\(^6\)

Let \(\gamma^i_w \in (0, 1)\) denote the fraction of labor in country \(i\) allocated to the production of wine and \(1 - \gamma^i_w\) is the fraction of labor in that country allocated to the production of cloth. Total output under full employment in country \(i\) is then \(y^i_w + y^i_c = (1 - \gamma^i_w)\frac{L^i_w}{a^i_w} + \gamma^i_w\frac{L^i_c}{a^i_c}\). To close the model, markets clear globally for each product. In the case of cloth: \(\sum_i \gamma^i_w L^i_c = \sum_i \gamma^i_w\frac{L^i_c}{a^i_c}\), and similarly for wine. We assume trade balance for each country: \(L^i(x^i_c + x^i_w) = \gamma^i_w\frac{L^i_w}{a^i_w} + (1 - \gamma^i_w)\frac{L^i_c}{a^i_c}p\). This leads to what we will call integrated equilibrium (IE), where all countries in the network possibly engage in trade and all markets clear. For the world market of wine, this is given by:

\[
\sum_i \gamma^i_w \frac{L^i_w}{a^i_w} = \left(\frac{\beta}{\alpha + \beta}\right) \left[ \sum_i \left(\gamma^i_w \frac{L^i_w}{a^i_w} + (1 - \gamma^i_w)\frac{L^i_c}{a^i_c}p\right) \right]
\]  

(3)

and similarly for the world market of cloth. This is standard Ricardo. The nice thing about writing the model in this way is (i) we can easily generalize this to more countries and more goods, (ii) we can add network structure into this model. To look at a specific network, we can just shut down the necessary channels: say we want to look at a particular network in the form of a line with France in the middle, we set the interdependent demands of the particular countries that are not directly into trade, equal to zero.

We can then solve the model from given primitives and compare the outcomes (in terms of \(\Delta\)) between any network that is possibly realized. In order to compare efficiencies across the resulting networks, our measure of efficiency is utilitarian, and we denote it as “global welfare”: \(\sum_i U^i\). The results are the following:

1. Equilibrium, stability and efficiency

- Like in an Arrow-Debreu market, the First Fundamental Welfare Theorem holds, and any equilibrium is Pareto optimal and efficient. The same rules for existence of equilibrium as in the Arrow-Debreu market apply for this setting. (However, multiplicity, not existence is the greater issue in networks).

- Stability in the dynamic game is defined by Pairwise Stability (Jackson and Wolinsky, 1996): given an observed network, does any node have an incentive to unilaterally cut a link and be better off, or can two nodes add a link and both be better off (at least one strictly)? The IE is Pairwise Stable, however a node would like to see the link between his partners severed in order to be better off (see externalities).

- Efficiency depends on utilities: if \(\alpha + \beta > 1\), a setting where one node gets to consume all bundles is efficient. If \(\alpha + \beta = 1\), then the IE is efficient, and all possible divisions of bundles across nodes are equally efficient. If \(\alpha + \beta < 1\) then any allocation that minimizes the differences in consumption bundles across nodes is efficient (depending on the ratio \(\alpha/\beta\)).

- With complete passthrough, it is possible to construct any IE in terms of network structure: one can put any node in the middle of a line, and achieve a Pareto optimal outcome. However, most of these constructed equilibria will never arise from the network formation game! It is however useful to note that for any given network, with complete passthrough, it behaves like an Arrow-Debreu setting. In other words, the set of outcomes of the IE is a subset of all possible outcomes (including the fixed networks) that behave like an Arrow-Debreu setting.

- In terms of betweenness centrality, a country that has large amounts of pass through will be the weak intermediary in the fixed network, and would be bypassed in the network formation game without trade costs. It might be interesting to measure this in reality, and look at the position of

\(^6\)Alternatively, one can set up a 2-stage game where links are formed in the first stage, and production and trade take place in the second stage. This is similar to the setup of Helpman, Melitz and Rubinstein (2008), where the authors take this to a 2-stage selection model in the spirit of a Heckman selection model, extended to account for firm heterogeneity. However, specialization patterns are not explicitly considered in their setting.
transfer or transport economies in the network (countries such as Belgium). Contrary to standard belief, these central countries might actually be worse off in this setting, and even hamper trade in a setting with trade costs.

**Proposition 1:** The Arrow-Debreu framework readily extends to any given network with the same properties (even if there are nodes that are not directly connected or not in anonymous markets) [Results are available upon request].

**Collorary 1:** The set of realized IE outcomes is a subset of the Arrow-Debreu set of possible outcomes. (In order to show this, we need to formalize that the possible network structures in equilibrium are determined by relative supply (the Arrow-Debreu set). The realized outcomes in the Ricardian model are determined by the interplay of labor endowments, comparative advantage and relative demands. Let’s show this with an example: figure 2 shows the relative supplies and relative prices for the 3 countries, 2 goods case. The relative supply is the staircase curve which maps out the possible networks 1 to 7, of which one is formed where relative demand equals relative supply. The countries are England, Portugal and France, and the goods are cloth \( c \) and wine \( w \). We assume that \( \frac{a_c}{a_w} < \frac{a_p}{a_w} < \frac{a_c}{a_w} \). Also note that Portugal will never be the center of a star, as it is not at the ends of the comparative advantage chain.

- Case 1: All countries specialize in wine. There is no trade possible.
- Case 2: England produces both cloth and wine, the rest specializes in wine.
- Case 3: England specializes in cloth, the rest specializes in wine.
- Case 4: England specializes in cloth, Portugal produces both, France specializes in wine.
- Case 5: England and Portugal specialize in cloth, France specializes in wine.
- Case 6: England and Portugal specialize in cloth, France produces both cloth and wine.
- Case 7: All countries specialize in cloth. There is no trade possible.

Since there is Bertrand competition in homogenous goods inside sectors, there is no trade between countries that specialize in the same good. With this in mind, we can draw the possible networks. The 7 cases are given in figure 3. The top left network corresponds to cases 1 and 7, the other networks are cases 2-6.
2. Prices, quantities, trade and specialization

- Prices, quantities, trade and specialization are all determined by market clearing prices in the general equilibrium setting. If complete passthrough exists, and there are no trade costs, the structure of the network does not influence these outcomes.
- In the 3 goods, 2 country case, different prices on each leaf exist initially, dictated by different relative technologies on each leaf. In equilibrium, prices will settle. However, if central action can be taken by the node, it can extract surplus from its trading partners if it can sustain price discrimination through domestic lump sum transfers, taxation, ...

3. Link formation

- Even with zero trade costs, the IE is not complete, following from corollary 1. If \( n > 2 \) countries, no complete network is possible with 2 goods, as specialized countries in the same good cannot trade with each other, and there is at most one diversifying country.
- There is a Pareto optimal outcome, where Portugal is not involved with trade, as Portugal is indifferent between trading and autarky.
- Portugal can switch specializations, depending on the order of movement. However, we assume here it is costless to switch production to the other sector.

**Proposition 2:** If we look at the case with \( n > 2 \) goods, we can have a complete network if and only if the productivity matrix has full rank, i.e. in the case that technologies are not linearly dependent. [Results are available upon request].

4. Position of countries in the network

- If central nodes arise from the game, it is not clear whether they can use their centrality to extract surplus from its neighbors. However, in their setting, it is the behavior of firms that renders the position of the countries in the network useless.
- With complete passthrough, it doesn’t matter who is where in the network, as any efficient allocation can be achieved from market clearing prices. Each produces, trades and consumes the same bundles as in IE. For \( N \) countries: if countries are completely specialized, outputs are calculated directly from the endowments, and demand determines relative prices. If incomplete specialization occurs, relative prices over the whole network are dictated by the one country that diversifies, and demand then determines the relative outputs. Everyone gains from trade, except the one country that diversifies. The structure of the network doesn’t matter at all if we have market clearing prices and complete passthrough with no trade costs.
• For an exogenous network structure: the position of countries in the network affect trade patterns and equilibrium outcomes. However, the amount of passthrough is different per network structure: if France is the center of a star, no passthrough is needed in a calculated setting (endowments not given in this proposal). If England is the center of a star, it passes through some wine from France to Portugal, since it is only producing cloth. If Portugal is the center of a star, it has to pass through both wine from France to England and cloth from England to France.

5. Externalities

In the benchmark case, we always end up in integrated equilibrium. However, some externalities exist:

• If we move from a dyad to a triad, one country of the dyad is always worse off than before: the country that is not involved in the new trade. Vice versa: in IE, a third country is always strictly better off if the other 2 would break their link. \(^7\)

• If a node diversifies, it dictates the prices over the whole network. With \(N\) countries and 2 goods, only one country can diversify, and \(N - 1\) countries have to follow world prices, making some better off, and others worse off. At the same time, that country is indifferent between trading and not trading, but global welfare increases in the IE compared to the case where this country would not trade.

• If we restrict passthrough trade (make it costly somehow), while retaining equilibrium prices, then networks can break down (e.g. Portugal or England as center of star cannot sustain trade relationships. However, what is a rationale for restrictions on passthrough if no trade costs exist, nor policy?

6. Policy

• Related to the neoclassical models of trade (Samuelson, 1939), one can distinguish between a setting with one household per economy (where every household is weakly better off from trade), or more households per economy (where there are winners and losers from trade, depending on their initial endowments). If there exists only one centralized firm in the country, it could sustain price discrimination along both leaves if feasible. If many firms are competing in prices, however, might it be sustainable using domestic lump-sum transfers or taxation?

4 Empirical evidence

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5 Extensions

In this section, we briefly consider relaxing one or more of the assumptions set in section 1 [Results are available upon request].

1. Incomplete passthrough

• In our setting, a country cannot block passthrough and be better off resulting from that action. However, if for some reason passthrough is not possible, a network might not be stable and it can evolve to another outcome.

2. Variable trade costs

\(^7\)This relates to our empirical finding in De Bruyne, Magerman, Van Hove (2013). There we find that clustering has a net negative effect on bilateral trade volumes. However, when we split up trade flows by extensive (number of goods traded) and intensive (value of the goods traded) margins, we find that clustering has a negative effect on the extensive margin (less goods are traded with my partners, if my partner start trading themselves), and a positive effect on the intensive margin (the goods that are still traded have a comparative advantage, and these trade flows will increase).
• The benchmark model issues no trade costs at all. We can assume iceberg trade costs, identical for all goods and for all countries per trade link that is active. This will lead to different prices over the network. (But will it alter the efficiency?).

• Efficiency depends on the utility specification, equilibrium does not. Does this mean that adding variable trade costs will still lead to stable outcomes that are efficient?

3. Fixed costs of exporting

• In the spirit of Melitz (2003) and Freund (2000), we look at the fixed costs of link formation. When costs are sunk, with imperfect competition history can matter as firms sequentially enter markets versus multilateral liberalization.

• One question is if we can have perfect competition and fixed costs at the same time? Our conjecture is that once the fixed cost is sunk, firms will only export to that country, leaving nothing for the home market since firms are identical inside a country. This would leave the home market unserved, which is not an equilibrium. In our simple example, 6 equilibrium prices will arise. We can solve for these simultaneously: production price + trade cost equals world price. Then we need to equate the marginal utility to the price of each good in each location.

4. Imperfect competition

• Perfect competition leads to global market clearing prices with price-taking firms in equilibrium. However, a country in the middle could extract all surplus from its partners if it is able to price discriminate even with perfect competition. We can look at a setting where only one aggregate firm exists per country with the same production possibilities as the country. Our conjecture is that it can price discriminate in markets, extracting all surplus from its partners, and pay its workers the weighted average of the returns (while still making zero profits in equilibrium).

• Brander and Spencer (1985) type of setting: Assume the third country has consumer only, no production. Can country 1 and 2 collude?

5. Domestic transfers, taxation and trade policy

• Later we would like to check if taxation can lead to externalities in the network: In order to sustain the different prices along each leg, can a country tax the imports of one good so that both prices equalize? This could lead to net gains for the country in question.

• International transfers would be in the form of goods. Can they lead to stable outcomes?

6  Comparative statics

Here we briefly outline the types of shocks we are exploring in our setting. We focus on shocks that are not typically modeled in international trade models, but those that can be measured using a network representation:

1. One node enters the network (say China opens up to trade, and has a strong comparative advantage in cheap low-technological labor with respect to the rest of the world). How will links reform? How does this affect the social welfare of the previous countries, and global welfare? How does it affect specialization patterns? If we assume specialization is costly, a large offset in specializations will have important welfare effects for individual countries and maybe even clusters of countries. What are the second-order effects of respecialization?

2. A new link is formed in the existing network (a new bilateral trade agreement is signed). How does this affect trade flows between partners in the agreement and not in the agreement?

3. Shock in technologies in a country: how do prices, wages, specialization and welfare change over the network? Will new links form or old links drop? Does the position of the country in the network matter for propagation?
4. Look at a uniform continuous decrease of variable trade costs over time, from $t \to \infty$ to $t = 0$. Define range of endowments and costs for which the first country pair opens up to trade. Then for second, third etc. Is there a particular network that arises (form), and do we see externalities arise? Write this as partial derivatives and go from $c > c^0$ to $c^1 < c = c^0$, $c^1 < c < c^0$, up until $c^t = \zeta$.

5. Add variable costs and fixed costs. Same exercise. Which countries will incur the fixed cost first? How does this affect the structure of the network? If we conversely build up from an empty network, will history matter, i.e. do we end up at the same networks?

[Results are available upon request]

7 Conclusion

TO BE COMPLETED.

References


