Knowledge-driven vs trade-driven globalisation: Understanding asymmetric trade effects

Richard Baldwin and Yuan Zi, Graduate Institute, Geneva

Preliminary and incomplete first draft: December 2016

1. INTRODUCTION AND STYLISED FACTS

Globalisation's advance is typically conceptualised as having been driven by falling trade costs. This could be called the trade-led conceptualisation of globalisation.

Trade-led globalisation tends to produce relatively symmetric outcomes since freer trade lets every nation do what they do best and trade for the rest. As long as the cross-sector competitiveness profiles of nations differ, wages and prices adjust so that each nation is the low-cost producers in at least something (Ricardo 1817). From a welfare perspective, globalisation in this paradigm is like two football clubs exchanging players; both clubs gain if an exchange actually takes place.

In this tradition, the post-1990 radical reductions in communication costs are modelled as lowering frictional trade barriers (Grossman and Rossi-Hansberg 2008, Heish et al 2016, etc). But does this characterisation of the information and communication technology (ICT) revolution really capture its main impact on globalisation? Maybe it really matters that ICT is directly facilitating the flow of ideas across borders and only lowering trade costs indirectly? Maybe we should consider a conceptualisation of globalisation which is also knowledge-led, instead of only trade-led?

Knowledge-led globalisation tends to produce asymmetric outcomes for two very good reasons. First, knowledge tends to be non-rival, so cross-border flows of knowhow are more like spreading something rather than exchanging something. Second, the flows tend to be asymmetric given that knowhow is abundant in a handful of advanced economies and scarce everywhere else. To follow on the football analogy, knowledge-led globalisation is like the coach of the better football club training the worse-teams' players on the weekends. The impact of this knowledge crossing team boundaries will be asymmetric in many ways (and gains from trade are not guaranteed at the team level).

This paper focuses on one aspect of the asymmetries implicit in knowledge-led globalisation, namely its impact on the manufacturing of parts and components.

ICT made production unbundling possible, wage differences made it profitable

In the knowledge-led view of globalisation, revolutionary advances in ICT mattered since they made it possible to coordinate complex production arrangements internationally. This fostered offshoring but the change was asymmetric. It was a revolutionary boost in developing nations' abilities to export parts, but less so for G7 parts exporters.

The point is that until the ICT revolution, the export of parts was lopsided. G7 firms sold parts and components to manufacturers in other G7 nations and to manufacturers in developing countries, but relatively few parts were exported from developing nations to G7 nations.

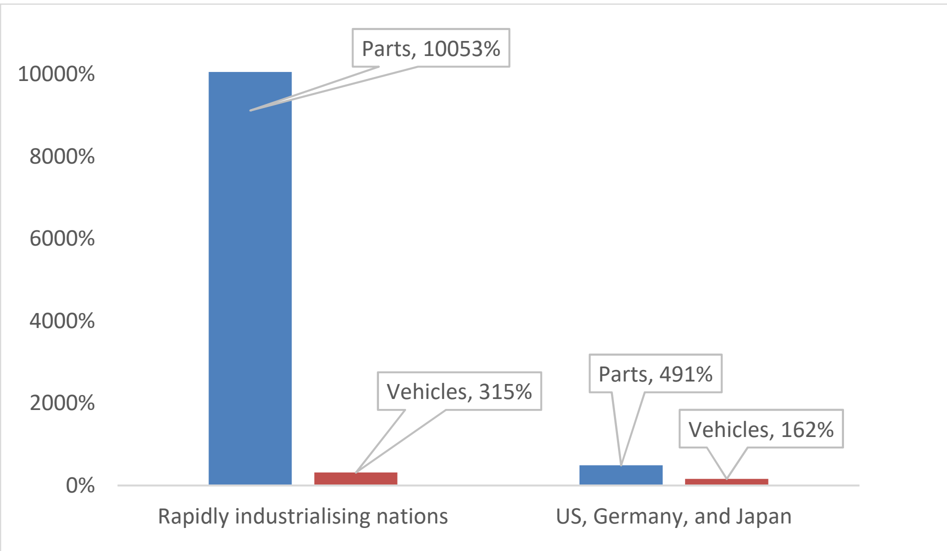
To put it differently, there is nothing surprising about Japanese firms selling transport equipment parts to Vietnam. Developing nation manufacturers have always had to deal with, or work around, the standards of G7 manufactures when importing parts. There really was no other option as two-thirds of all manufacturing was done in G7 nations and the G7 share of sophisticated parts and components was even higher. This is why it was always relatively easy for G7 firms to export parts to developing nations, at least from a technical point of view.

Developing-nation manufactures, by contrast, found few foreign buyers for their parts since it was costly or even impossible for G7 firms to verify the parts' quality, reliability and fit with the rest of the process. All this changed when the G7 firms could monitor developing-nation factories in real time and at a very low cost. The ability to observe and control what went on in developing nations factories in real time gave G7 firms the confidence to unbundle their production processes and shift labour-intensive stages in low wage nations. Moreover, since the internationalised factory had to work as a symphony, the G7-firms tended to offshore their managerial, technical and market knowhow along with the offshored production stages. It was, in essence, the increased cross-border flows of knowledge that drove this offshoring, not just the lower cost of moving goods.

An example of this can be seen by contrasting the growth of parts and final goods in the auto sector that was experienced by two groups of nations after the ICT revolution really picked up around 1990. The first is the three nations that had dominated global manufacturing for decades – the US, Germany and Japan – and the second is ten rapidly industrialising developing nations -- China, India, Indonesia, Ireland, Korea, Malaysia, Poland, Singapore, Thailand, and Turkey. (The focus is on autos and auto parts since the definition of parts and final goods is unusually clear in the trade data.)

Each bar in Figure 1 shows the overall growth of export values between 1988 and 2008. The figures show that the developing nations experienced faster export growth than the advanced nations in both final vehicles and auto parts. The really spectacular growth, however, was that of parts exported by the developing nations. Additionally, we can see that trade in parts grew fast than trade in final goods for both groups (due to the rise of international production networks).

Figure 1: Export growth for autos and auto parts for selected developing and advanced nations

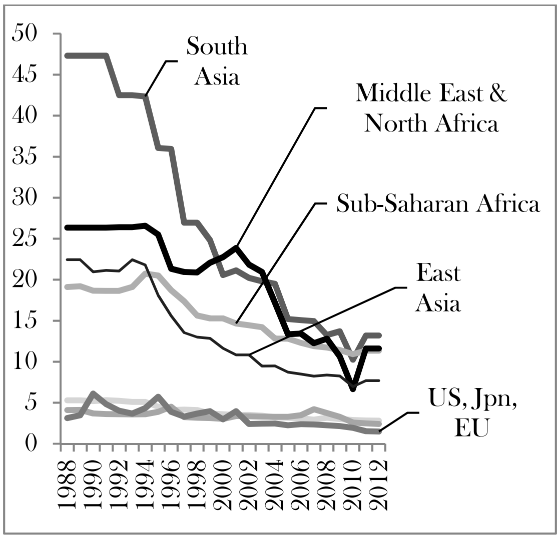


Source: WITS online database with author's elaboration. The rapidly developing nations compromise China, Korea, India, Poland, Indonesia, Thailand, Ireland, Malaysia, Singapore and Turkey.

If one insisted on sticking with the trade-led globalisation view – where falling trade costs is the only thing driving deeper integration – this asymmetric outcome could be modelled as an asymmetric trade opening. For example, it could be modelled as high-wage nations unilaterally lowering the cost of importing parts from low-wage nations.

This rationalisation would account for the facts, but this would be twisting facts to fit theories, not theories to fit facts. When it comes to tariffs on manufactured goods, it was the developing nations which have unilaterally lowered their tariffs, not the advanced nations (Figure 2). The other main component of falling trade costs, transportation technology, is most sensibly modelled as having an even-handed impact, so it is hard to think that the striking features of Figure 1 can be accounted for by changes in trade costs alone.

Figure 2: Asymmetric tariff cutting since 1988



In short, advancing globalisation massively stimulated trade in autos and auto parts, but it acted as an asymmetric opening. It is as if the ICT Revolution and associated changes in policy reduced the barriers to exporting cars and car parts, both from North to South and South to North, but it was especially powerful in reducing the barriers facing auto-parts exporters based in developing nations.

Asymmetric globalisation

The key goal of this paper – which is in a very preliminary stage – is to establish empirical correlations between countries level of development and the asymmetric impact that globalisation has had on parts production and exports. To help interpret the correlation, the paper also presents some simple theory that explains how knowledge-led globalisation quite naturally leads to more asymmetric outcomes than trade-led globalisation.

The baseline intuition for our modelling is straightforward. Globalisation can be thought of as international arbitrage. When it comes to trade-led globalisation, lower trade costs allow each nation to buy-low-and-sell-high. That is, each nation exports goods that tend to be relatively low cost domestically in exchange for goods that tend to be high cost domestically. Yet since it is the relative price that matters, lower trade costs tends to stimulate trade in a symmetric manner. This is nothing more than the principle of comparative advantage.

When it comes to knowledge-led globalisation, the arbitrage is across international differences in the knowledge per worker. Since this ratio is vastly higher in advanced nations than it is in developing nations, the easier flow of ideas tends to create asymmetric flows of knowledge from the advance economies to the developing economies.

To put it differently, trade-led globalisation is where lowering the cost of moving goods allows each nation to better exploit its comparative advantage. Knowledge-led globalisation has aspects of this, but globalisation of this type usually changes nations' comparative advantage in a way that is usually asymmetric.

The next section presents some preliminary empirical evidence for the asymmetric trade impact. After that, we present a simple model of trade-led and knowledge-led globalisation and show that the latter tends to have asymmetric trade effects while the former does not. The final section presents our concluding remarks.

2. SPECIFICATION AND DATA DESCRIPTION

The goal of this section is to move beyond the auto sector example and establish a correlation between asymmetric parts trade outcomes and development status, and then attempt to associate the asymmetry with ICT.

2.1. Empirical Model: Trade in parts

To this end, we follow Egger et al. (2011) and estimate a standard multiplicative gravity model:

$$Y_{odt} = exp(\delta + \varphi ITC_t + \boldsymbol{M_{od}}\boldsymbol{\alpha} + ICT_t\ \boldsymbol{M_{od}}\boldsymbol{\beta} + \boldsymbol{Z_{odt}}\boldsymbol{\gamma})\ e_{odt},$$

where Y_{odt} is the exports in part and components from origin country o to destination country d at time t. δ is the constant, ICT_t is our measure of ICT technologies and φ captures the average effect of the ICT technology advance.

To capture the impact of ICT revolution, we divide countries into three groups, 'North' (so-called Headquarter Economies), 'South' (selected developing nations that have a potential for GVC participation, so-called Factory Economies), and the rest. Correspondingly, $\boldsymbol{M_{od}}$ is a vector of dummies that differentiate five different groups of trade flows: North to North (N2N), North to South (N2S), South to North (S2N), South to South (S2S), and all other trade flows. With this, we allow for trade effects to differ across the groups; this will show up the elements of the parameter vector $\boldsymbol{\beta}$.

Our leading hypothesis is that $\beta_{S2N} > \beta_{N2S}$, i.e. that falling costs of communication tends to stimulate the export of parts from Factory Economies to Headquarter economies more than vice versa.

As standard in running regressions with interaction terms, we also control for $\boldsymbol{M_{od}}$ itself, with $\boldsymbol{\alpha}$ capturing the fact that trade flows vary across trading groups on average. Due to perfect collinearly, we drop dummy of "the other trade" and its interaction with ICT_t.

Since the technology advance is a global rather than country, or bilateral-specific concept, we start with regressions that have no controls to establish unconditional correlations correlation between the asymmetric export growth and the advance of ICT technology.

To refine the association between ICT and the trade outcomes, we then add in standard gravity model controls to see if the unconditional results carry through. Those controls and fixed effects are summarized by $\boldsymbol{Z_{odt}}$ and their effects are captured by $\boldsymbol{\gamma}$.

We employ Poisson-maximum-likelihood (PPML) estimator to utilize the information carried by zero trade flows and, more important, to account for heteroskedasticity in trade flows data. As advocated by Santos Silva and Tenreyro (2006), the standard log-linear OLS approach results in inconsistent coefficient estimates. Standard errors are heteroscedasticity robust and clustered at the country-pair level to allow for autocorrelated residuals.

2.2. Data Source and definitions

There are three main sources of the data -- UN Comtrade database for bilateral trade flows, World Bank World Development Indicators for ICT measures, and CEPII gravity database for standard gravity controls.

To construct our dependent variable, the bilateral trade flows in parts and components, we take the list of machinery parts and components by 6-digit Harmonized Commodity Description and Coding Systems (HS6) from Kimura and Obashi (2010). Depending on the version of the HS classification, they identified 433 to 445 goods at HS6 level to be parts and components. We take bilateral trade flow data over the period of 1965 – 2015 from UN Comtrade Database. The data is only classified by Standard International Trade Classification, Rev.1 (SITC1), therefore we the trade flow data at the SITC1, 5-digit level and reply on the crosswalk between HS and SITC1 provided by World Integrated Trade Solution (WITS) to identify trade flows in parts and components under SITC1 classification. We then sum up the data to obtain our final measure of bilateral trade flows in parts and components, which varies by origin, destination, and time.

We construct two preliminary measures to proxy the ICT revolution. The first measure is simply a year dummy which equals one after the year 1990. Admittedly crude, it is exogenous and captures the basic idea that the advance in Information and Communication Technology accelerated at the 1900s and started to transform international trade. The second measure we use is the logged world sum of internet and fixed & mobile subscribers. Both data are taken from the World Development Indicators. As it turns out, world telephone subscription and internet users started to take off around mid-90s and may offer a more precise measure of ICT advance. The validity of this measure, nevertheless, reply on its growth is not driven by or correlated with a particular country's development.

The data for standard gravity controls, namely the dummy for RTAs, Common currency and Colonial ties, are taken from the Gravity Database of CEPII. The RTA dummy equals to one if there is any regional trade agreement in force between a country pair at time *t*. Colonial ties dummy equals to one if a pair currently in a colonial relationship, and Common currency dummy equals to one if the country pair shares common currency at time *t*.

Throughout the exercises, we focus on countries whose GDP exceeds a billion US dollars in 1990. We define "North" as the G7 and "South" as other countries whose manufactures exports accounts more than 10% of merchandise exports in the year 1985.

Finally, as noted by Cheng and Wall (2005), "Fixed-effects estimation are sometimes criticized when applied to data pooled over consecutive years on the grounds that dependent and independent variables cannot fully adjust in a single year's time." To avoid the disadvantage of pooling gravity data over consecutive years, we follow what is standard in the literature (e.g. Baier and Bergstrand 2007) to use only data every five years.

2.3. Estimation Results

Table 1 shows the estimated effect of ITC_t on gross trade flows of parts and components, with ICT_t being measured as the post-1990 dummy, and logged sum of world telephone and internet users, respectively. Colum (1) report the PPML estimates with post-1990 dummy being the ICT measure, without any controls as our benchmark case. The estimated coefficients on N2N, N2S, S2N are positive and significant, while the coefficient on S2S is negative and significant, suggesting South to South trade significantly lower than the average prior to the year 1990. The positive coefficient on ICT itself suggests an average export growth after the 90s. The four interaction terms are all positive and significant; suggesting all four groups of the trade increased more after year 1990 compared other trade flows. The coefficients that we care the most are the

Table 1. ICT Effects on Asymmetric Opening.

Parts and Component Trade						
	ICT: post-1990 dummy			**ICT: world internet and telephone users**		
	(1)	(2)	(3)	(4)	(5)	(6)
N2N	6.51***			7.21***		
	(0.28)			(0.27)		
N2S	3.36***			3.95***		
	(0.18)			(0.20)		
S2N	2.11***			2.87***		
	(0.22)			(0.23)		
S2S	-1.06***			-0.40*		
	(0.17)			(0.21)		
N2N*ICT	0.42***	1.18**	0.63	-0.13***	0.34	0.34
	(0.13)	(0.58)	(0.70)	(0.05)	(0.24)	(0.30)
N2S*ICT	0.77***	0.71	0.13	0.04	0.03	-0.04
	(0.12)	(0.52)	(0.66)	(0.05)	(0.18)	(0.26)
S2N*ICT	1.77***	1.15**	0.65	0.32***	0.22	0.27
	(0.22)	(0.58)	(0.70)	(0.08)	(0.24)	(0.31)
S2S*ICT	2.26***	0.92*	0.35	0.51***	-0.02	-0.05
	(0.16)	(0.52)	(0.66)	(0.06)	(0.18)	(0.26)
Colonial ties			-0.53***			-0.54***
			(0.16)			(0.16)
RTA			-0.05			-0.04
			(0.06)			(0.06)
Common Currency			-0.11**			-0.11**
			(0.05)			(0.05)
ICT	1.60***			0.72***		
	(0.10)			(0.04)		
Constant	-6.54***			-6.86***		
	(0.15)			(0.17)		
ot, dt, od fixed effects	N	Y	Y	N	Y	Y
$\beta_{S2N} - \beta_{N2S}$	**1**	**0.44**	**0.52**	**0.28**	**0.19**	**0.31**
$H_0: \beta_{S2N} < \beta_{N2S}$						
p-value of H_0	**0.00**	**0.07**	**0.03**	**0.00**	**0.18**	**0.06**
Observations	255816	167,883	117,892	255,816	167,883	117,892

*Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.*

coefficients on S2N*ICT and N2S*ICT, as their difference informs us to which extend ICT revolution has boosted South to North trade more than North to South trade. As we can see estimated coefficient on S2N*ICT (β_S2N) is more than twice the of estimated coefficient on N2S*ICT (β_N2S). As we work with non-linear estimation models, we cannot directly interpret our coefficient directly, but Wald test suggest we can reject the null hypothesis that $\beta_{S2N} < \beta_{N2S}$ at 1% level.

In Column (2) we include origin-country-year, destination-country-year, and origin-destination pair dummies to control for all country-pair time-invariant characteristics and all characteristics that are specified to a country in a given year. When adding the full set of fixed effects, only interaction terms could be identified. Since our variables of interest (the interaction terms) are essentially a product of one variable that varies either across time or country pairs, a lot of their variations were drawn out by the fixed effects. Nevertheless, even in this case we still find the coefficient on S2N*ICT greater than that of N2S*ICT, with the null hypothesis being rejected at the 10% level.

In Colum (3), we further control for the impact of having colonial ties, RTAs, and/or sharing a common currency. Both the coefficient on colonial ties and common currency are negative; the results are likely driven by the group of African countries that has little parts and components trade. The coefficient on RTA is slightly negative but statistically insignificant. The coefficients on S2N*ICT and N2S*ICT are not significant either, but their difference are positive and we can reject the null hypothesis that $\beta_{S2N} < \beta_{N2S}$ at 5% level. The fact that we could reject the null hypothesis even with a full set of fixed effects and other gravity controls is assuring, as they net out a significant part of the variation of our variables of interest, which could easily render our estimation insignificant.

Colum (4) repeated the empirical excise of Colum (1) but with ICT being measured as the logged sum of world Internet and telephone users. In this case, we find no robust evidence that North to South trade increases more than average with the advance of ICT; moreover, North to North trade grow slower than the world average when ICT advances. But we see coefficients on both S2N*ICT and S2S*ICT are positive significant, suggesting the beneficial effect of ICT is particularly strong for South to North and South to South trade. The story of asymmetric opening holds in Column (4) as well, as we reject the null hypothesis that $\beta_{S2N} < \beta_{N2S}$ at 1% level. In Column (5) we include the full set of fixed effects. In this case, the coefficient on S2N*ICT is greater than that of N2S*ICT, but both are so imprecisely estimated that we fail to reject the null hypothesis. Nevertheless, in Column (6) when we add additionally other gravity controls, we are able to reject the null that $\beta_{S2N} < \beta_{N2S}$ at the 10% level again. In nutshell, with both ICT measures, we are able to confirm the existing of "asymmetric opening" in most of the cases, even when the full set of controls take out a significant part of the variation of our variable of interest.

2.4. Summary of preliminary results

We view these regressions as suggesting that the example shown in Figure 1 is not an isolated exception. Even when we look at a broad range of traded goods there seems to be a robust correlation between the impact of advancing ICT on trade in parts and components, and development status. Our findings should not be viewed as establishing causality, and certainly more work is needed before we can be fully confident that the correlation is well-established.

We turn now to a simple logical framework that helps us organising our thinking about how more knowledge crossing borders could result is a trade asymmetry of the type described.

3. THE BASIC MODEL

We depart from a set up akin to that of Baldwin and Venables (2013), working with two-countries, North (N) and South (S), and assuming perfect competition and constant returns.

Production of each "good" involves the assembly of many "parts"; specifically, each good is produced from a continuum of parts that are indexed by $i \in [0,1]$.

The parts are produced independently and are assembled simultaneously into goods, so there is no sequentiality in the parts manufacturing process.

The per unit cost of producing part 'i' in S is ws times as, where ws is the wage in S and as is the unit labour input coefficient; the unit cost in N is isomorphic but denoted with the subscript N.

To reflect the developed versus developing nation features of offshoring, we assume that N has an absolute advantage in all parts so, $a_S > a_N$ for all i, although this plays no role until we consider knowledge-based globalisation.

In addition to production costs, each part needs to be inspected for quality compliance; the per part quality-control cost is θ_N in N and θ_S in S; we normalise θ_N to be zero.

Finally, the assembly of parts into goods uses one unit of every part together with a_N and a_S units of labour in N and S respectively.

If parts need to be shipped between nations, the per unit cost of importing parts into N and S are τ_N and τ_S respectively (τ is a mnemonic for trade costs).

As in Baldwin and Venables (2013), we assume all consumption of goods takes place in N. If a good is assembled in S, the cost of importing a final good into N is T_N.

We assume that the patents for all goods are held by N-based firms and they are the ones choosing the sourcing of parts and location of assembly plants.

In this preliminary draft, we take the wages as parameters.

3.1. Cost minimization allocation of parts and final good production

It proves convenient to choose units of each part such that N's production and inspection cost, $w_N a_N(i)+\theta_N$, equals unity for all i, and to introduce the notation b(i) for S's production and inspection costs, namely:

$$b(i) = w_S a_S(i) + \theta_S(i) \tag{1}$$

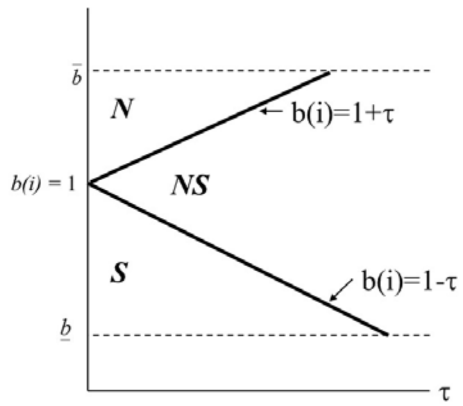
To be concrete, the technology is such that b's are distributed uniformly, i.e. $\underline{b} < b(i) < \overline{b}$ and $\underline{b} < 1 < \overline{b}$. The lack of sequentiality allows us to reorder the parts such that we can use the b's as the index rather than the underlying i.

Using this notation, we can define b(i) as N's comparative advantage in part i, since N is the low cost producer for all parts where b(i)>1.

Due to trade costs, the cost minimising sourcing of parts depends upon the local of assembly. When assembly is in N, the cost of sourcing part i from N is 1, while the cost of sourcing it in the S is $b(i)+\tau_N$.

The cost-minimising sourcing of parts can be calculated with the help of Figure 3 taking the two τ's as identical for the moment. While the choice is along the i-dimension, we can characterise the solution in terms of the b's. Specifically, only for parts whose b's are below 1-τ is sourcing from S is cheaper. The set of such parts thus depends upon τ as show by the set ***S*** in the diagram.

Figure 3: Cost-minimising sourcing of parts



When assembly is in S, it is cheaper to source from N all parts where b(i)>1+τ; this set is shown as ***N***.

Taken together, the solution to the cost-minimisation is characterised by three sets. ***S*** and ***N*** for parts that are always cheaper when bought from S and N (respectively), and ***NS***, which is the set of goods whose sourcing co-locates with assembly. When assembly is in S, it is cheaper to source the parts in ***NS*** from S and the reverse is true when assembly is in N.

Given this, the cost of assembly in N is:

$$C_N = w_N a_N + \int_{\underline{b}}^{1-\tau} \left(b(i)+\tau\right) dF(i) + \int_{1-\tau}^{\bar{b}} 1\, dF(i) \qquad \textbf{(2)}$$

the cost of assembly in S is:

$$C_S = w_S a_S + \int_{\underline{b}}^{1+\tau} b(i) dF(i) + \int_{1+\tau}^{\bar{b}} \left(1+\tau\right) dF(i) \qquad \textbf{(3)}$$

4. TRADE- VERSUS KNOWLEDGE-DRIVEN GLOBALISATION

As per the introduction, we seek to model the key differences between economic integration that is driven by lower trade costs that permit nations to better exploit their comparative advantage and economic integration that is driven by the cross-border movement of knowledge. We start with the trade-driven globalisation process.

4.1. Trade-driven globalisation

Consider first the pattern of trade and offshoring when globalisation is driven by falling trade costs only, starting from trade costs that are sufficient high to imply that all parts and goods production is in N (namely, $\tau > \underline{b}$).

As τ falls, the production of parts is progressively offshored from N to S as can be seen in Figure 3 (the range of parts in set ***S*** increases and τ falls). This would be associated with a rise in parts exports from S, and a rise in the foreign value-added content of goods produced in N.

Once a sufficiently wide range of parts production has been offshored to S, it may become cheaper to assemble in S and ship the good back to N rather than ship to parts for assembly in N. This happens when τ is low enough such that:

$$C_N > C_S + T_N \quad \textbf{(4)}$$

We define τ' as the threshold level of τ where assembly shifts to S.

We assume for at least some goods, this inequality will hold at τ=0, so that the assembly of at least some goods will shift from N to S during the trade-driven globalisation process. Depending upon the configuration of costs, this need not hold for all goods.

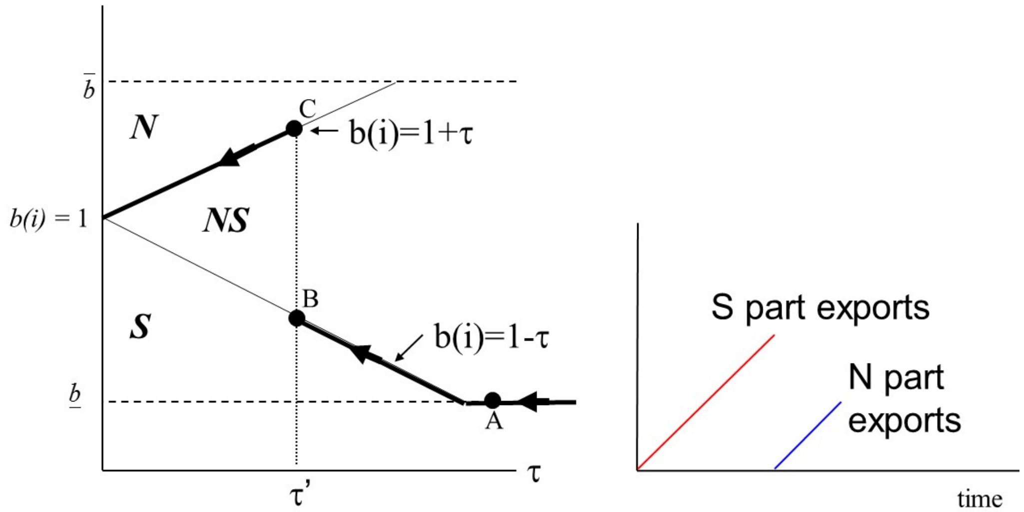
If T_N falls along with τ, the shifting of assembly happens at a higher τ'.

4.1.1. Focus on a single good

To illustrate the basic trade-driven globalisation process, consider an individual good for (3) holds for τ < τ'.

At high levels of τ (e.g. point A in Figure 4), all parts are made in N and so assembly in N is also cheaper than assembly in S. To build intuition, note that from this initial situation, τ dampens S's comparative advantage in parts, so falling τ tends to encourage production and export of S parts. That is, as τ falls, S's cost advantage can be better exploited, so an increasing range of parts are sourced from S, as the system moves towards point B. This is associated with rising parts exports from S and rising foreign value-added content in N goods production.

Figure 4: Typical trade-driven globalisation evolution



For τ below the threshold level τ', it becomes cheaper to assemble the good in S instead of N. At this point, the burden of trade costs shifts from S to N. That is, from point C onwards (i.e. to left), the falling trade costs allow N to better exploit its comparative advantage in parts, so further reductions in τ result in more parts being exported from N and a rise in the foreign value-added in S production.

Note that the jump in assembly's location implies what Baldwin-Venables call "offshore overshooting". In particular, when the jump from B to C occurs (i.e. when assembly is offshored), a wider range of parts are produced in S than is justified on pure production cost terms (remember N has a native comparative advantage in all parts with b>1). As trade costs fall further, some parts production is re-shored to N.

The implied pattern of parts trade is shown in the right panel assuming τ falls over time. At first S parts exports rise, then they drop to zero and N's parts exports begins to grow. The key point is that falling trade costs lead to a fairly symmetric outcome in the sense that it does not generally tend to favour parts exports from S.

We believe this simple illustration reflects a deep truth. Falling trade costs do not naturally explain asymmetric trade outcomes.

4.1.2. Many goods sectors

It is trivial to extend this to the situation where there are many goods sectors with many different cost configurations.

As τ falls, the growth of S's parts exports will depend upon the share goods that are still assembled in N, and, likewise, N's parts export growth will depend upon the share of goods assembled in S.

If there is a fixed proportion of goods assembled in S and N, the parts export growth of N and S will be both positive and both roughly proportional.

The simple reason is that trade-driven globalisation is allowing parts producers in both nations to better exploit their pre-existing comparative advantage.

However, since some good-assembly operations are moving from N to S during the process, there is a presumption that N parts exports would grow faster than those of S. This is, of course, the opposite of the stylised facts in Figure 1. We turn now to investigating whether knowledge-led globalisation can account for the observed asymmetries.

4.2. Knowledge-drive globalisation

There are two types of knowledge in our model; one is linked to quality control, and the other is linked to production technology, name the a's.

The first type is associated with costly quality control of parts. N-based firms, who control all the production processes, find it more expensive to check quality of parts made in S due to the cost of moving ideas across borders. That is to say, it is expensive to get knowledge about quality and processes that affect quality between the two nations. As communication costs fall, the ideas move more cheaply and the cost of quality control fall. This is the first aspect of knowledge driven globalisation and it involves the asymmetric lowering of θ_S since N-based firms already know the quality of the parts they are producing in N (θ_N is normalised to zero).

The second can be thought of as firm-specific technology 'lending' whereby an N-based firm combines is superior technology (i.e. $a_N < a_S$) with lower cost S labour to produce parts as in Baldwin and Robert-Nicoud (2014).

Given the definition of b(i), it is clear that knowledge-driven globalisation of this type will shift comparative advantage in S's favour. Both types of knowledge crossing borders lowers the cost of producing parts in S without change the production cost in N.

To be concrete, we introduce a functional relationship, namely $a_S(i)= a_N(i)+\chi i$, where χ (a mnemonic for communications costs) is a parameter governing the distribution of comparative advantage. This implies that N has better production technology than S in all parts except i=0 where the two technologies are equal, i.e. $a_N(0) = a_S(0)$. This is illustrated in the left panel of Figure 5. Knowledge-driven globalisation of this second type is modelled as a fall in communication costs, (chi is a mnemonic for communication costs) that facilitates the application of N technology to S workers, namely a fall in χ.

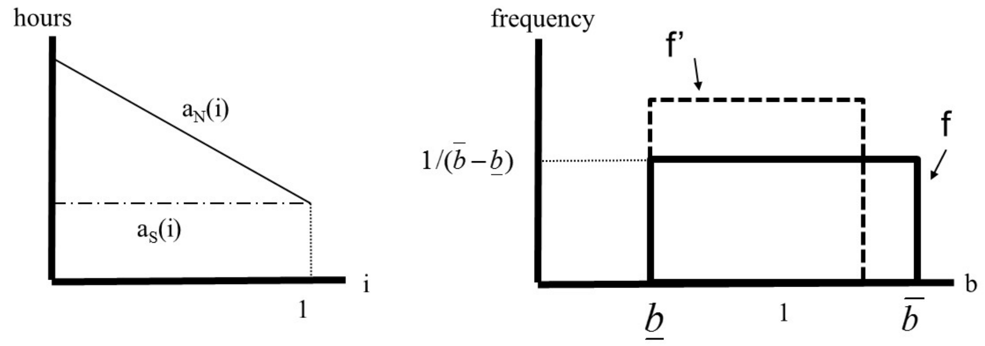
Again, for simplicity's sake, we assume that $\theta(i)=\chi\Theta i$, so that falling χ lowers the cost of quality control in S relative to the cost in N.

The impact of this sort of globalisation can be seen in Figure 5 as a shift in the distribution of b from f to f'. This implies an unambiguous increase in the mass of parts where S is more competitive than N for any given level of trade costs.

One way to think of this outcome is that knowledge-led globalisation is not allowing nations to better exploit their comparative advantage, it is shifting comparative advantages.

Observe that this shift in comparative advantage is in the background. The solutions to the lowest-cost sourcing problem is the same in terms of b's, but the mass of N parts with a particular b changes. Thus the analysis in Figure 3 is unaffected.

Figure 5: Production technology and distribution of comparative advantage



4.2.1. Focus on a single good

Given that S has a comparative advantage in any part where $b < 1$, the leftwards shift of probability mass shown in **Error! Reference source not found.** will mean that falling τ will tend to have a more asymmetric impact on S's exports.

For goods where assembly is still in N, the falling trade costs (moves from point A to point B in Figure 6) will lead to a faster rise in parts exports from S. The point is that S's part exports will rise due both to lower trade costs and the shifting comparative advantage. Of put differently, we would see rising parts exports from S if only τ fell, or only χ fell.

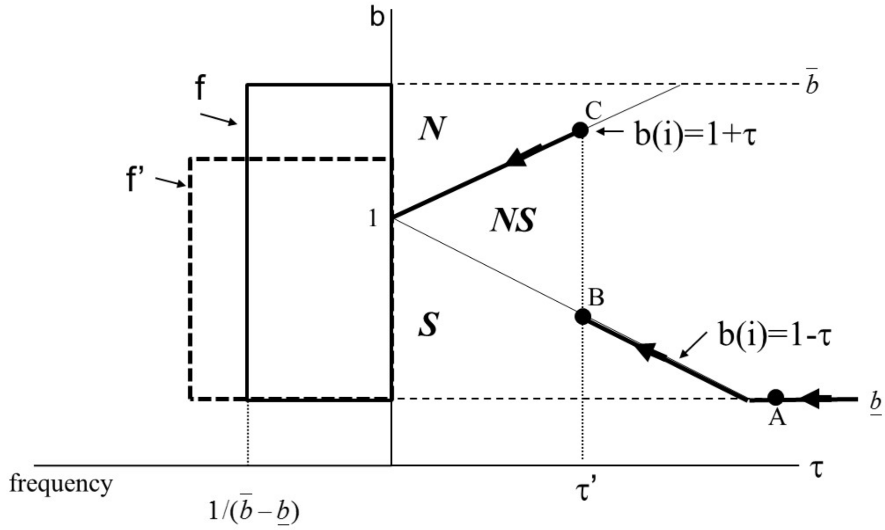
Likewise, for goods where assembly has moved to S, the rise in N parts exports from falling τ (moves from point C) will be less marked than before the shift in comparative advantage since N firms are losing comparative advantage even as lower τ is allowing others to exploit their comparative advantage..

In either case, the value added originating from S embedded in all goods will rise as χ falls.

As before, we could formally model a many good set up where some assembly was in S and some in N and the shift was endogenized.

In summary, knowledge-led globalisation favours production of parts in S and disfavours parts production in N. Consequently, it should tend to be associated with a S exports of parts growing faster N's.

Figure 6: Asymmetric parts production and exports with knowledge-led globalisation



5. CONCLUDING REMARKS

To be written

References

Baier, Scott L., and Jeffrey H. Bergstrand. "Do free trade agreements actually increase members' international trade?." Journal of international Economics 71.1 (2007): 72-95.

Baldwin, Richard & Frederic Robert-Nicoud , 2014. "Trade-in-goods and trade-in-tasks: An integrating framework," Journal of International Economics, Elsevier, vol. 92(1), pages 51-62

Baldwin, Richard and Antony Venables (2013). Spiders and snakes: Offshoring and agglomeration in the global economy, Journal of International Economics 90 (2013) 245–254.

Cheng, I-Hui, and Howard Wall. "Controlling for heterogeneity in gravity models of trade and integration." Federal Reserve Bank of St. Louis ReviewJan (2005): 49-63.

Dixit, A.K. and G. M. Grossman (1982) ‘Trade and Protection With Multistage Production’ *The Review of Economic Studies*, Vol. 49, No. 4 , pp. 583-594

Egger, Peter, et al. "The trade effects of endogenous preferential trade agreements." American Economic Journal: Economic Policy 3.3 (2011): 113-143.

Fujita, M. and J. Thisse (2006) ‘Globalization and the evolution of the supply chain: who gains and who loses?’ International Economic Review, 47, pp 811-836

Grossman, G. M., Rossi-Hansberg, E., (2008). Trading Tasks: A Simple Theory of Off-shoring, American Economic Review, 98, pp 1978-97.

Grossman, Gene M. & Esteban Rossi-Hansberg, 2008. "Trading Tasks: A Simple Theory of Offshoring," American Economic Review.

Hanson, G. H., Mataloni, R. J., Slaughter, M., (2001). Expansion strategies of US multinational firms, in: Rodrik, D., Collins, S. (Eds.), Brookings Trade Forum 2001, 245-282.

Hanson, G. H., R. J. Mataloni, and M. J. Slaughter, (2005). Vertical production networks in multinational firms, Review of Economics and Statistics 87, 664-678.

Harrigan, J. and A.J. Venables (2006) 'Timeliness and agglomeration', Journal of Urban Economics, 59, 300-316.

Helpman, E., (1984). A Simple Theory of Trade with Multinational Corporations. Journal of Political Economy 92, 451-471.

Helpman, E., (2006). Trade, FDI and the organization of firms', Journal of Economic Literature, XLIV, 589-630.

Helpman, E., Krugman, P.R., (1985). Market Structure and Foreign Trade, MIT Press, Cambridge MA.

Hsieh, Chang-Tai, Nicholas Li, Ralph Ossa and Mu-Jeung Yang (2016). "Accounting For The New Gains From Trade Liberalization," NBER WP 22069.

Hummels, D. (2001). "Time as a Trade Barrier." Department of Economics, Purdue University, Lafayette, IN.

Hummels, D., D. Rapoport, and K.-M. Yi, (1998). Vertical Specialization and the Changing Nature of World Trade. . Federal Reserve Bank of New York Economic Policy Review 4, 79-99.

Hummels, D., Ishii, J. and Yi , K-M., (2001), The Nature and Growth of Vertical Specialization in World Trade. Journal of International Economics 54, 75-96.

Hummels, D., J. Ishii and Kei-Mu Yi, (1999). "The nature and growth of vertical specialization in world trade," Staff Reports 72, Federal Reserve Bank of New York.

Johnson, R. C. and Noguera, G. (2009) "Accounting for Intermediates: Production Sharing and Trade in Value Added". Unpublished, http://sites.google.com/site/robjohnson41/.

Jones, R. W., Kierzkowski, H., (2001). A Framework for Fragmentation, in: Arndt, S.W. Kierzkowski, H., (Eds), Fragmentation: New Production Patterns in the World Economy, Oxford University Press, Oxford.

Jones, R.W., (2000). Globalization and the Theory of Input Trade, MIT Press, Cambridge.

Kimura, F., Y. Takahashi and K. Hayakawa, (2007). "Fragmentation and parts and components trade: Comparison between East Asia and Europe," The North American

Journal of Economics and Finance, Elsevier, vol. 18(1), pages 23-40, February.

Kimura, Fukunari, and Ayako Obashi. "International production networks in machinery industries: Structure and its evolution." ERIA discussion paper series 2010-09 (2010).

Leamer, E.,and J. Levinsohn (1995). International trade theory; the evidence, in: Grossman, G., Rogoff, K., Handbook of International Economics, Vol. 3. North-Holland, Amsterdam., pp1339–1394

Markusen, J. R., (2002). Multinational Firms and the Theory of International Trade, MIT Press Cambridge.

Markusen,J.R. and A.J. Venables (2007) 'Interacting factor endowments and trade costs: a multi-country, multi-good approach to trade theory', Journal of International Economics, 73, 333-354

Ng, F. and A. Yeats, (1999). Production sharing in East Asia; who does what for whom and why. World Bank Policy Research Working Paper 2197, Washington DC.

Silva, JMC Santos, and Silvana Tenreyro. "The log of gravity." The Review of Economics and statistics 88.4 (2006): 641-658.

Venables, A.J. (1996), 'Equilibrium locations of vertically linked industries', International Economic Review, 37, 341-59.

Yeats, A., (1998). Just how big is global production sharing World Bank Policy Research Working Paper 1871, Washington DC

Yi, K-M., (2003). Can Vertical Specialization Explain the Growth of World Trade? Journal of Political Economy 111, 52-102.