Information Technology, Globalization, and Growth: Role for Scale Economies, Terms of Trade, and Variety

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Forthcoming in
After the Fall: Re-Growing Economic Growth
Danny Leipziger and Otaviano Canuto, editors
World Bank

February 14, 2011

Abstract

This paper considers three channels through which globalization of information technology products may affect economic growth: Terms of trade in IT products in international trade, economies of scale in IT production and trade, and variety in IT consumption and trade. The empirical question relevant for policy makers is, what is the relative magnitudes of these channels. To catalyze economic growth and enhance performance, should policymakers promote IT exports to exploit economies of scale in production? Or, should they promote imports and domestic consumption of a variety of IT products to gain from falling IT prices, get more variety, and through these channels support faster TFP? Using a sample of 36 countries for 2000-2007, the findings are: (1) Importers of IT gain relatively more than exporters, on average, from the declining prices of IT coming through international trade. (2) Despite falling IT prices, most exporters enjoy positive economy-wide benefits of trading in IT because of economies of scale in production. (3) The extent of variety of traded IT products is related to the deviation of a country's experience from that of the average country in its peer group. Controlling for trade patterns, the countries that are below average (in terms of economy-wide benefits from trade in IT) are also those that import and export the least variety of IT products. This suggests that gains to variety in consumption outweigh gains from economies of scale in production.

Overview and Summary of Findings

Three channels support growth from international trade in information technology products.

- **Falling IT prices favor IT consumers and net importers**: Quality adjusted prices of IT products continue to fall over time. All else equal, consumers (net importers) tend to benefit from improved terms of trade in these products, whereas producers (net exporters) tend to lose purchasing power as the terms of trade turns against them. Based on terms of trade alone, superior economic performance and growth would be supported by being a consumer and net importer of IT products.

- **Increased variety of IT products used by business enhances innovation**: Total factor productivity is positively associated with diffusion of IT throughout the economy. Based on this notion alone, innovation and economic growth are likely positively associated with the increased variety of produced and imported IT products to meet the diverse business and consumer needs in an economy.

- **Economies of scale favor high volume IT producers and net exporters**: Total factor productivity is positively associated with the scale of production of IT products. Based on this notion alone, concentrated production and net export of a relatively few IT products would support superior economic performance and growth.

This paper reports on research on the relative magnitudes of these channels.

- Using a broad-based measure of the economy-wide benefits of IT confirms that **importers of IT gain relatively more than exporters, on average, from the declining prices of IT coming through international trade.** Larger economic gains are associated with a market structure and policy environment in which the presence of IT facilitates changes in business products, processes, and workplace practices.

- **Despite falling IT prices, most exporters enjoy positive economy-wide benefits of trading in IT because of economies of scale in production.** Many net exporters apparently import (at falling prices) inputs into the supply chain, then exploit significant economies of scale in production of IT for export. The combination of the terms of trade benefit on the imported inputs and the economies of scale benefit on the export yields an overall economy-wide gain. For most net exporters, however, the economy-wide benefit is still less than that enjoyed by net importers of IT.

- **The extent of variety of traded IT products is related to the deviation of a country's experience from that of the average country in its peer group**. Controlling for trade patterns, the countries that are below average (in terms of economy-wide benefits from trade in IT) are also those that import and export the least variety of IT products. This suggests that gains to variety in consumption outweigh gains from economies of scale in production.

What are the policy implications of these findings?

- **Exploiting economies of scale in production can be a jumping-off point for higher growth**. Countries that neither produce nor use IT have the lowest growth prospects.

- However, a growth strategy that focuses on **production mainly for export gives up potential gains** to growth that come from importing, consuming, and/or producing a wide variety of IT products.

- Therefore, **for most countries, an increased variety of traded IT products (both exports and imports) is associated with higher TFP and therefore higher growth**. The increased variety of IT products used in the domestic economy is associated with more wide-spread diffusion of IT throughout the economy, and the associated increased TFP, higher GDP per capita and growth.

1. Introduction

This paper considers three channels through which globalization of information technology products may affect economic growth. The three channels are: Terms of trade in IT products in international trade, economies of scale in IT production and trade, and variety in IT consumption and trade.

With regard to the terms of trade channel, the fall in quality-adjusted prices of IT products would tend to favor consumers of IT, so that net importers (production less than consumption) would experience the faster economic growth. But, given the fragmentation of production of IT into a global supply chain, it is not so simple to measure terms of trade.

Production of IT products exhibits important economies of scale. So, a country could specialize in a segment of the supply chain by importing a narrow set of imports (to exploit the terms of trade gain) and then exporting a narrow set of IT products (to exploit economies of scale in production). So concentrated trade patterns and being a net exporter by producing more than consuming could yield faster growth.

Finally, the availability of a wide variety of IT products is a potential source of economic gain. Greater variety means that more domestic users find good matches between products and needs, which increases productivity and growth. Variety of exports might further support growth to the extent that higher prices and profits comes with higher variety.

The empirical question relevant for policy makers is, what is the relative magnitudes of these channels. What data relate economic growth to production, consumption, and international trade in IT products? To catalyze economic growth and enhance performance, should policymakers promote IT exports to exploit economies of scale in production? Or, should they promote imports and domestic consumption of a variety of IT products to gain from falling IT prices, get more variety, and through these channels support faster TFP?

The next section addresses measurement issues, and describes a metric and apparatus—so-called social surplus—with which we can evaluate, in general terms, the relationships between production and consumption of a transformative innovation, and economy-wide productivity and growth. Section 3 presents an overview of patterns of production, consumption, and trade in IT products, and reviews the literature on the relationship between information technology and growth. Section 4 takes the social surplus apparatus to the data on information technology production, consumption, and trade to consider the relative importance of economies of scale, variety, and terms of trade for economic well-being and foundations for growth.

2. Measuring Economic Growth: Getting to the Social Surplus Concept

2.1 Productivity measures: Labor vs TFP

Productivity and productivity growth are standard ways to measure the foundation of economic growth. A more productive economy is one where resources are allocated efficiently so as to generate the highest amount of output without inflationary strain, resource waste, or environmental degradation. In the long run, a more productive economy can generate more possibilities for consumption and business investment.

Labor productivity is output per unit labor input and is often a key measure of the foundations for economic growth. Increased labor productivity can be achieved without innovation, but rather through increases in the capital stock. Diminishing marginal returns to capital inputs, however, suggest that labor productivity is an incomplete measure of the foundations for economic well-being and growth.

Total Factor Productivity (equivalently termed Multifactor Productivity) measures the extent to which an economy can generate more output using the same resources. By definition, increased TFP implies innovation and transformation in how resources are combined—this innovation and transformation could be observed as new products or could be observed as changes in business processes and different workplace practices. Increased TFP implies increased growth in the sense that the economy can produce more output to allocate towards final demand.

2.2 GDP vs GNI and the role for terms of trade and TFP

GDP and GDP per capita are standard measures of economic performance and growth. They incorporate increases in resources, production of new products, as well as innovations in business process and workplace practices. But, being aggregates, these measures do not distinguish between components of economic growth, as for example between consumption or investment or net exports.

In a globalized economy with international trade, and in an environment of rapid innovation in new products, processes, and practices, the aggregate GDP measure may mask important sources of economic growth that influence the economic well-being of the population. That is, if there is a structural trend in a country's terms of trade, gross national income (GNI) may be better measure of economic growth. For example, if a country has substantial imports of a product whose international price is falling—which implies that its terms of trade are improving—then real GDP understates the country's real domestic income, its purchasing power, and the economic growth that can be enjoyed by domestic residents.[1] Similarly, if an economy has a structural balance of

[1] See United Nations (2008) for general discussion of the terms of trade effect on GDP vs. GNI. See also Feenstra, et al (2007) for a further discussion of real production vs. real expenditure measures and their implications for welfare analysis. Kohli estimates overall terms of trade effects for 26 countries (2004) and Canada (2006).

payments surplus, GDP overstates the extent to which the fruits of economic growth are enjoyed by domestic residents.[2]

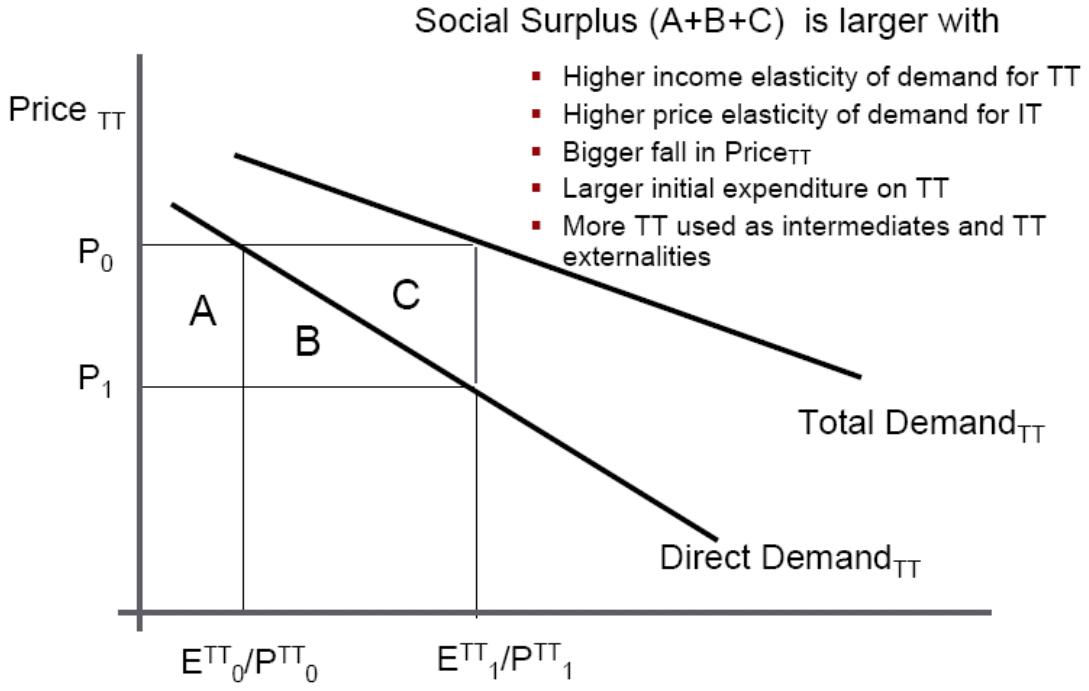
Considering trends in the terms of trade is relevant not only from the standpoint of purchasing power, but also from the standpoint of measuring productivity growth. Specifically, there is a mathematical isomorphism between changes in the terms of trade and changes in total factor productivity—an improvement in the terms of trade is equivalent to an innovation that increases TFP and economic growth.[3]

2.3 The Social Surplus concept, transformative technology, and economic growth

TFP is difficult to measure. Social surplus is another way to account for the accumulated gain and economic growth that a country gets as more and more buyers take advantage of a transformative technology.[4] From the standpoint of a final consumer, innovations that reduce prices yield direct gains, measured as consumer surplus. But, purchasing innovative products with falling prices yields indirect gains as well through cheaper intermediates and changes in production processes. Collectively, the spending power and investment decisions induced by the innovation fall on other parts of the economy, accentuating the value of the transformative technology for overall TFP and growth. The calculation of how much the overall economy gains from the falling prices associated with an innovation is called social surplus. Figure 1 shows an example of the social surplus apparatus for a transformative technology.

[2] The balance of payments surplus presumably is invested and thus there is an intertemporal trade-off between the generation today and future generations.
[3] See Crafts (2004) and Diewert and Morrison (1986) for mathematical details of this isomorphism, and see Morrison and Diewert (1991) for examples using Japanese and US data.
[4] See Bayoumi and Haacker, p. 11-12, but also Kohli and Feenstra as previously noted.

Figure 1: Transformative Technology (TT) and Social Surplus



The next section reviews the empirical evidence underpinning the facts of globalization of IT, and the assertions that diffusion of IT products enhance total factor productivity and economic growth. Section 4 calculates social surplus for a set of countries and considers the relationship between social surplus and the extent to which the economy may gain through direct demand for this transformative technology, as well as how the economy may gain through indirect demand for the transformative technology.

3. Literature on Information Technology and Economic Growth

There is a vast literature on the relationship between information technology (IT) and measures of economic growth.[5] This paper highlights a small subset of the literature which focuses on first, the relationship between economies of scale in IT production and economic growth, and second on diffusion of variety of IT and economic growth. We start with some observations on the globalization of production and trade of IT because it has bearing on the issues of economies of scale and variety of IT products in international trade.

[5] The term 'information technology' can include any combination of hardware, software, services, and communications. In specific empirical analysis, the included set can influence the results. Where it does, the text will be more explicit; otherwise the generic term IT will be used.

3.1 Changing patterns of international trade and domestic expenditure

That the information technology industries are greatly globalized in production, investment, and cross-border trade goes without saying. The OECD Information Technology Outlook addresses and quantifies numerous measures of the globalization of the IT industry, both goods and services. Additional assessments, predominantly for emerging markets and developing economies can be found in UNCTAD, Information Technology Report, and UNCTAD, World Investment Report. [6]

Although the global production of IT goods is highly fragmented, with production sites all over the world, some indicators suggest that production has become more concentrated over time, as key producers squeeze the maximum economies of scale in production from factories in the lowest cost locations.[7] In addition, an increase in exporters' revealed comparative advantage for information and communication technology goods over the 1990s[8] also points to some concentration of global production of specific parts and components, even as the production process of a wider variety of 'final' IT goods remains highly fragmented.

Data for information technology goods trade (Table 1) show both rapid changes in country ranking in the top exporters and importers as well as changes in trade concentration. The bottom line is that China+Hong Kong SAR exploded from 2% of global exports (ranked 14th) to 15% of global exports (ranked 1st) between 1990 and 2004. On the import side, China+Hong Kong SAR moved from 9th ranked at 4% of global imports to top ranked with 20% of global imports.

There were other changes in the trade landscape, even if not so dramatic. Between 1990 and 2004, the cumulative share of the top 3 exporters fell from 47% to 35%, suggesting less trade concentration. Who is in the top three changed: Japan dropped from top exporter with 20% of world exports in 1990 to be replaced by China+Hong Kong SAR with 15% of world exports in 2004. The United States stayed at number 2 exporter with 19% of world exports in 1990, but only 11% of world exports in 2004. The number 3 exporter was United Kingdom in 1990 (dropping to 10th in 2004), while Singapore rose from fifth to third ranked over the time period.

On the import side, concentration has changed little, but the rankings have changed. The top 3 importers accounted for about 40% of world imports from 1990 through 2004. The United States was the top ranked importer in 1990, accounting for about 20% of world imports, which is what China+Hong Kong SAR accounted for with its top ranking in 2004. China+Hong Kong SAR doubled its share of global imports from only 4% of imports in 1990 to 10% by 2000, and then doubled its share again to reach the 20% share

[6] Global fragmentation of production of IT services has begun relatively recently, and has started out more concentrated (India), but promises to become more globally disbursed. See for example the discussion in OECD Information Technology Outlook (2008) p 87. and UNCTAD Information Technology Report (2007).

[7] Mann (2006) p 33 on apparent concentration of production by US MNCs in low cost locations and Reed Electronics data .

[8] OECD, Information Technology Outlook (2008) p. 94-95.

in 2004. The U.S. slipped to number 2 with 15% of world imports. Among the other top ranking importers, Japan, Germany, and Singapore continue.

Table 1: Patterns of Globalization of IT in trade

Country Ranking and Concentration of Global IT trade				
	1990			
	Rank	Country	Share of World Trade	Cumulative Share
Exports	1	Japan	20.4	20.4
	2	United States	19.3	39.7
	3	United Kingdom	7.7	47.4
	4	Fmr West Germany	7.4	54.8
	5	Singapore	6.7	61.5
	14	China+Hong Kong	1.7	
Imports	1	United States	20.6	20.6
	2	Fmr West Germany	9.7	30.3
	3	United Kingdom	9.0	39.3
	4	France	6.5	45.8
	5	Italy	4.5	50.3
	9	China+Hong Kong	3.9	
	2000			
	Rank	Country	Share of World Trade	Cumulative Share
Exports	1	United States	17.0	17.0
	2	Japan	14.1	31.1
	3	Singapore	9.8	40.9
	4	korea	6.6	47.5
	5	Taiwan	6.4	53.9
	9	China+Hong Kong	4.2	
Imports	1	United States	20.3	20.3
	2	China+Hong Kong	10.0	30.3
	3	Japan	6.7	37.0
	4	Singapore	6.7	43.7
	5	Germany	5.9	49.6
	2004			
	Rank	Country	Share of World Trade	Cumulative Share
Exports	1	China+Hong Kong	15.2	15.2
	2	United States	11.0	26.2
	3	Singapore	8.7	34.9
	4	Japan	7.9	42.8
	5	Germany	6.9	49.7
	6	Taiwan	6.4	
Imports	1	China+Hong Kong	20.1	20.1
	2	United States	14.8	34.9
	3	Germany	6.5	41.4
	4	Singapore	6.2	47.6
	5	Japan	5.8	53.4
Source: Mann (2006) Table 2.2a; original data from UN Comtrade				

An interesting question is whether countries that rank highly in terms of global trade also rank highly in terms of domestic expenditure on information technology. A quick look at the data (Table 2) indicates that being deeply involved in global production and international trade in information technology does not necessarily correlate with what a country spends domestically on IT.

For example, the United States accounted for 45% of global expenditure on IT in 2000, shrinking to 36% by 2008. Both shares though, are substantially larger than the U.S. share in global IT trade. Japan and Germany have shares in global trade somewhat more similar to their shares in domestic expenditure. China+Hong Kong SAR's share of global expenditure, although it rose four times over and ranks sixth in global expenditure, remains quite small in comparison to the country's importance in global trade.

If a country's share of world trade and its share of global expenditure were the same, it suggests a balanced expansion path for the economy overall. Economies with a higher share in global trade than global expenditure suggests that IT is mostly a production platform for growth through international trade. On the other hand, if the expenditure share is greater than the trade share, this suggests that the economy is using IT internally for growth.

Table 2. Share of World Expenditure on Information Technology

Domestic Expenditure on Information Technology								
2000			2004			2008		
rank		share of world	rank		share of world	rank		share of world
1	United States	45.1%	1	United States	39.0%	1	United States	36.2%
2	Japan	15.9%	2	Japan	10.7%	2	Japan	9.1%
3	Germany	6.4%	3	Germany	7.3%	3	Germany	7.2%
4	United Kingdom	6.1%	4	United Kingdom	7.0%	4	United Kingdom	6.4%
5	France	4.8%	5	France	6.0%	5	France	5.8%
8	China+Hong Kong	1.5%	6	China+Hong Kong	3.3%	6	China+Hong Kong	5.2%
Source data: WITSA								

3.2 Evidence on the gains from producing vs. using information technology

We turn now to a review of selected empirical studies on the relationship between information technology and economic growth. The research agenda started with a focus on the how the ICT-producing sector generates economic growth though high estimated TFP and economies of scale in production.[9] Van Ark (2005), using data for 1979-2002 shows that total factor productivity in the ICT sector is higher than for other sectors: 8% in the ICT-producing sector vs. 3% in the ICT-using sectors. Chun and Nadiri (2008) find that in the US (1978-1999 data), economies of scale in ICT production accounts for 30% of TFP in the ICT-producing sector.

[9] Here-in the case where much of the extant research includes telecommunications (C) as well as information technology (IT) products, thus ICT.

However, from a policy-making perspective, looking to the ICT-producing sector for growth creates some problems. First, if the source of growth is production of ICT, then the sector must keep growing as a share of the economy to continue the overall expansion of economic activity. Second, if economies of scale in production are that important for TFP, any smallish country must produce primarily a narrow set of products for export, since domestic demand is unlikely to absorb all that is produced. Globalization of ICT production, and the rising share of China, as noted in the previous statistics, means tough competition in export markets. Finally, if growth from ICT comes only from producing ICT, then any country without an ICT sector would appear to be doomed to slow growth.

These conundrums encouraged researchers to look more deeply into how ICT was being *used* in an economy. Van Ark's 2005 closer examination of the ICT-producing vs. ICT-using sectors reveals that TFP in ICT-using industries increased 250% vs. only 30% in ICT-producing (79-95 vs. 95-02). Mun and Nadiri's 2002 research using U.S. data shows that networked information technology deployed in an ICT-using sector, particularly in services, and that linked forward to customers and backward to suppliers contributed importantly to cost reductions and TFP gains for the ICT-using sectors.

The research on ICT-using sectors found quite a bit of variation across countries in the TFP growth associated with ICT-use. Explaining this variation can inform policy making. One line of research looks at domestic institutions, human capital, and competition. Several research papers suggest that flexible labor markets enhance the impact of ICT on productivity growth, with more product-market competition having a similar and complementary result.[10] If businesses cannot (or have no incentive to) change product mix or change what workers do, then buying information technology is just an additional cost of doing business, rather than an enhancement to the business.[11] Further, if ICT investment takes place in a business environment lacking in strong international competition, productivity growth also lags.[12] Another line of research, particularly relevant for developing countries, finds that there needs to be a balance between human capital and investment in ICT before domestic use of ICT yields productivity and growth.[13]

A different direction for research focuses on how variety in products relates to TFP. Research on all types of products (not just ICT), finds that increased export variety is associated with 40% of the difference in measured TFP across countries. Feenstra and Kee (2007) attribute the bulk of this finding to variety in trade in electronics products. On the import side, a higher variety of all types of imports accounts for about 25% of TFP growth in developing countries.[14] If there is an insufficient variety of ICT products, the business community may find only poor matches to its needs, there would be less use of ICT and thus lower productivity and growth.

[10] OECD (2003a); Van Ark, Inklaar and McGuckin (2003) and Gust and Marquez focus on continental Europe.
[11] See case examples from developing economies in Mann, Eckert, and Knight (2000).
[12] Shih, Kraemer, Dedrick (2007).
[13] Seo and Lee (2006), Pohojola (2001), Dewan and Kraemer (2000), Orbicom (2005).
[14] Broda, Greenfield, Weinstein (2006).

In sum, even though TFP in the IT-producing sector is higher and economies of scale in production are quite important, the results of research on the relationship between information technology and economic growth increasingly points away from production of information technology and more to how information technology is used by businesses in an economy and what features of the economy are most conducive to that use. What with globalized production of ICT, where quality-adjusted prices are falling, international trade offers a more compelling avenue to buy ICT. Thus international trade in ICT may play a particularly important role in TFP growth in the ICT-using sectors.

4. International Trade in IT and the Social Surplus Measure of Economic Growth

Despite the obvious relationships, little of the literature on information technology and growth addresses the nexus of international trade in IT and economic growth. However just as the domestic focus shifted from the IT-producing sector to the IT-using sectors, this section shifts the focus from the domestic sources of growth to the global sources of growth from international trade in IT. The main reason for this shift is that with increased globalization of production and international trade, the decline in quality-adjusted prices of IT products has very different implications for producers of exported IT vs. consumers of imported IT. But it is also the case that this fragmentation of production around the world enables some countries to establish significant economies of scale in production in certain IT products. How do the terms of trade balance against the economies of scale, and what role is there for variety in supporting economic growth?

4.1 International trade in IT and social surplus—The hypothesis

Information technology is a transformative technology. Its quality-adjusted global price is falling, which should promote imports and greater use of the technology, with gains to social surplus, productivity, and economic growth the result. Yet, special economic zones in some countries focus on production for export, rather than for the domestic use. Whereas production and export of IT products obviously should not directly harm an economy, [15] declining prices for IT products means that the terms of trade (export prices compared to prices of imported products) are moving against these producers. Thus, the gains to the domestic economy that do come from producing IT for export (through economies of scale, for example), are partly offset by the opportunity cost of not using those resources to produce IT (or other) products with increasing value in domestic markets or in international trade. How important is production vs consumption for getting the gains from IT, considering the trade dimension?

The apparatus of social surplus is a crucial ingredient to investigating the relationship between economic growth and being an IT producer vs. being an IT buyer (or, somewhat in between, which is the case for most economies). The first step estimates social surplus for a set of countries. The second step uses the production--expenditure balance as a measure of international trade in IT. The final step considers why countries differ from each other beyond being net producers (exporters) or net consumers (importers) of IT.

[15] Assuming that the targeting of certain sectors does not lead to corruption or other inefficient activities.

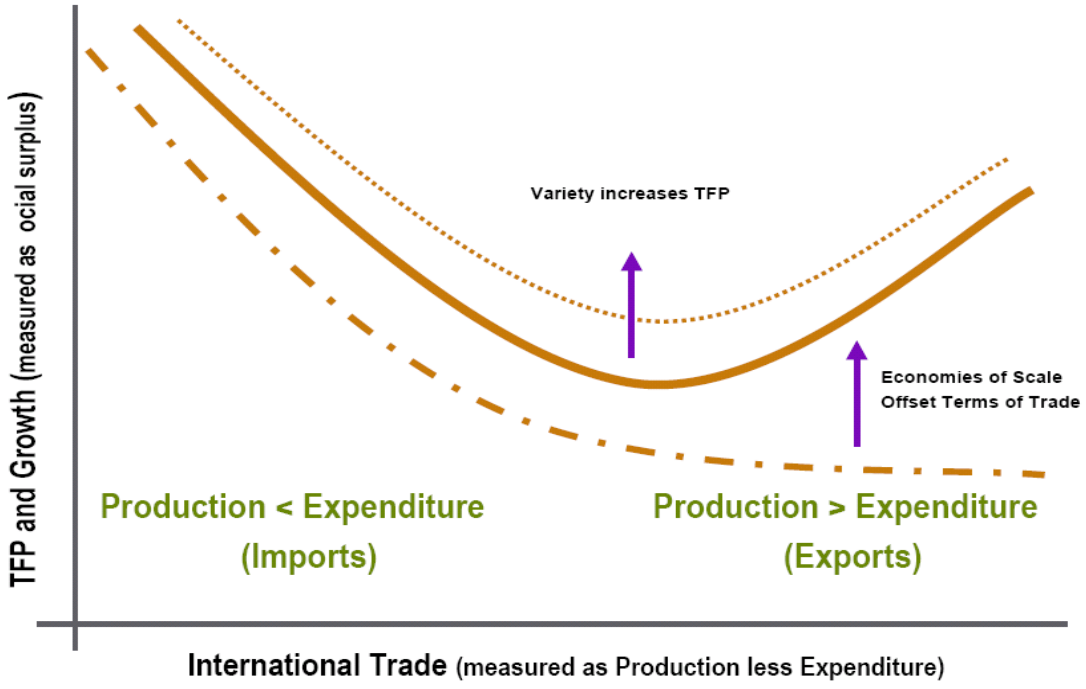
Figure 2 sets out the hypothesis based on the previous literature. First, the terms of trade effect: The quality-adjusted falling prices of IT favor IT consumers and importers. Based on terms of trade alone, social surplus should be negatively correlated with the difference between production and expenditure (or imports), as shown by the negative sloped dot-dash line.

However, economies of scale favor high volume IT producers, who, as discussed are most likely exporters too. Total factor productivity is positively associated with the scale of production of IT products. So, social surplus may be higher for high volume producers and exporters, which tilts the dotted line up, creating a 'U' shaped relationship between social surplus and the production--expenditure (trade) balance.

Third, research suggested that greater variety of IT products, including imports, used by business supports total factor productivity and social surplus. A greater variety of exports likely achieve relatively higher prices, which offsets the otherwise deleterious terms of trade effect for exporters. Therefore, all else equal, increased variety would tend to shift up the 'U' shaped curve.

If this is the set of hypotheses, what do the data reveal?

Figure 2: Growth and International Trade in IT: The Hypothesis

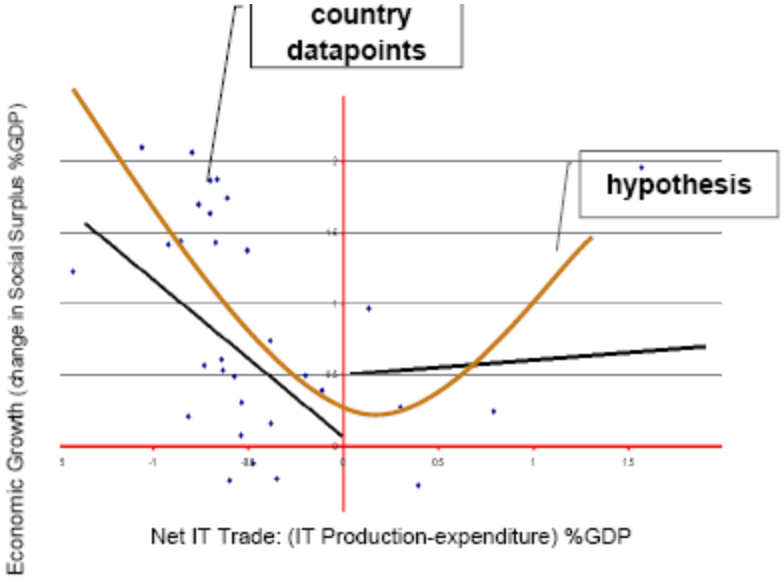


4.2 Patterns of IT Trade and Social Surplus – The Evidence

The first step is to calculate social surplus. Following the discussion in Section 2.3, the main ingredients to this calculation are data for each country's real GDP, real IT prices, and real production and real domestic expenditure on IT. The estimated price elasticity of demand and income elasticity of demand for IT also are needed.[16]

Social surplus is calculated as the average for 2000-2007 for 36 countries. Figure 3 shows the relationship between this metric of economic growth (social surplus as a share of GDP) and trade in IT products (measured as production less expenditure, as a share of GDP for the years 2003-2006, averaged). The linear segments show the linear trend (regression) relationship for importers taken alone, and for exporters taken alone.

Figure 3: Growth and International Trade in IT—The Calculations



Overall, the collection of individual estimated country data points matches the basic hypothesis that importers of IT (production < expenditure) enjoy relatively higher social surplus (TFP and growth) compared with countries that are exporters of IT (production > expenditure). But, there is significant country dispersion around the average regression relationship that bears further examination.

[16] Mann (2010) gives more details on the construction of the data and calculation of each country's social surplus.

Figures 4a and 4b show the two sides of the previous diagram along with more country detail. These calculations reveal several important points that bolster the empirical research already cited, and partly support the hypothesis that social surplus and imports of IT products are positively related through the terms of trade.

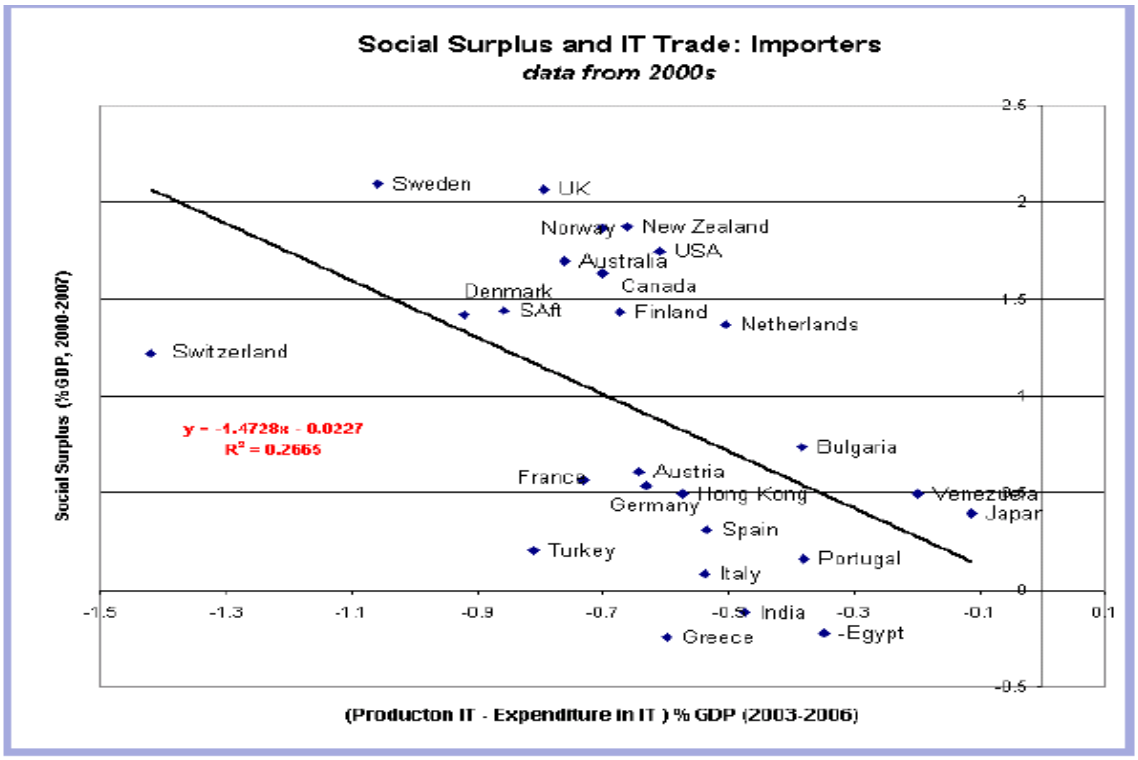
First, consider the importers (Figure 4a), those where production of IT is less than expenditure on IT. For these countries, falling IT prices increase social surplus because more consumers are accumulating the benefits of falling IT prices both directly and indirectly as IT diffuses through the economy. The trend line reveals the positive relationship between social surplus and imports of IT: That is, the increase in social surplus (e.g. accumulated gain to buyers from declining IT hardware prices) is greater the larger is the (negative) gap between production and expenditure on IT hardware—e.g imports. The trend relationship is somewhat greater than unity (-1.5) indicating that a 1% increase in IT imports (production less expenditure) is associated with a 1.5% increase in social surplus. This greater-than-unitary association is consistent with other research already cited on the productivity enhancing diffusion benefits and externalities associated with using IT.

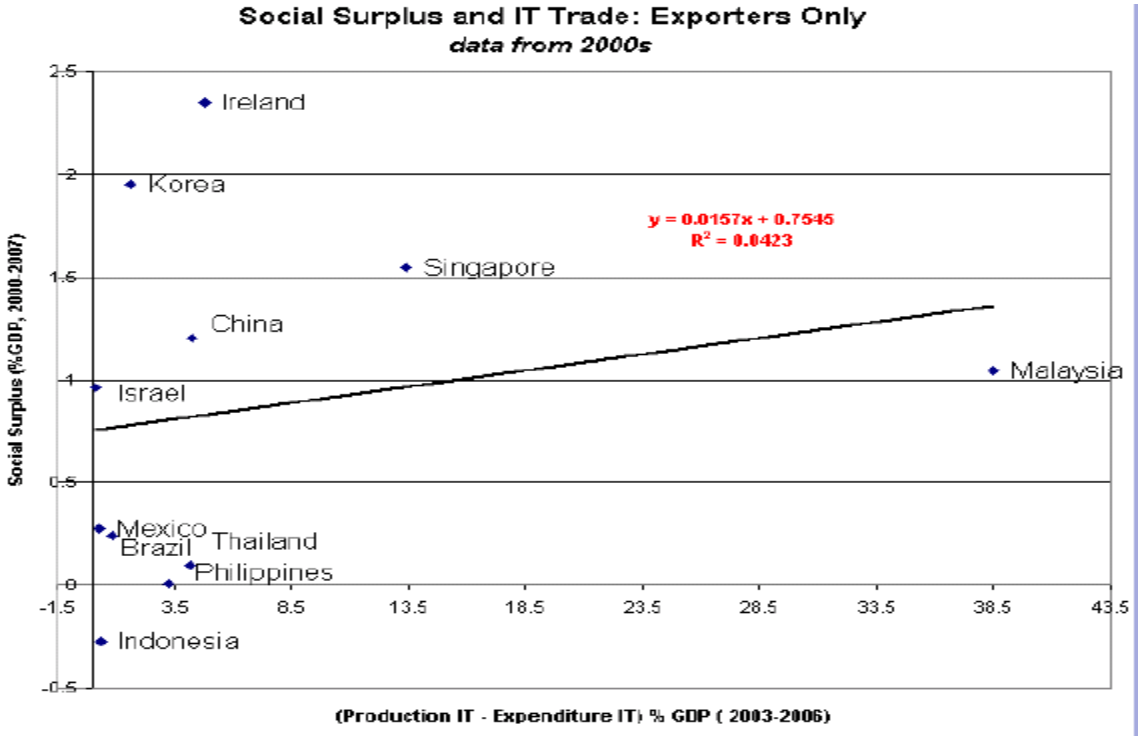
These estimates of social surplus use data from the 2000s and can be compared to Bayoumi and Haacker's estimates using data from the 1990s as discussed in Mann (2009). First, the relationship between social surplus and imports is stronger in the 2000s than in the 1990s (e.g. a steeper slope of -1.5 vs -0.9). This implies that translating IT imports into social surplus, productivity, and economic growth is stronger in the recent decade as compared to the 1990s. This is a bit surprising since the quality-adjusted decline in IT prices actually slowed in the 2000s compared to 1990s (from about 11% per year to about 8.5% per year).[17] The observation that the relationship is stronger suggests that more countries are getting greater social surplus gains from their IT expenditures and imports. In other words, countries on average are experiencing greater changes in products, processes, and practices through using IT during the past decade compared to during the 'dot-com' decade.

Around the trend line, there is quite a dispersion of individual country experience. Some of the dispersion could be due to higher variety of imports or IT expenditure which accentuates social surplus gains. Some dispersion could be due to institutional and business environment factors that affect the relationship between IT diffusion and productivity growth, as discussed in the literature. These are points to which we will return in Section 5.

[17] The calculations for net price decline for each country incorporate domestic price changes and exchange rate changes. But the dominant feature driving the data is the IT price decline in the US data.

Figure 4a and 4b: Social Surplus and IT Trade: Country Detail





Now consider the exporters, where production of IT exceeds expenditure on IT. For these countries, two forces directly influence the underlying IT prices associated with the social surplus calculation. On the one hand, exporters of IT hardware should experience a worsening of their terms of trade, reducing social surplus. On the other hand, cost efficiencies from economies of scale in production may offset the terms of trade effect and increase social surplus.

In fact, the estimated trend coefficient near zero (0.0157) suggests that that there is virtually no relationship between being an exporter and social surplus, which was also the case using data from the 1990s.[18] On the other hand, the observation that the trend line cuts the y-axis at around 0.76% indicates that a country does gain social surplus from being a producer and exporter, it is just that there is not a strong relationship between the magnitude of production, exports and social surplus. Therefore, the hypothesized relationship between social surplus and just the terms of trade is not, on average, supported by the data. As suspected, economies of scale could offset the pure terms of trade effect.

As for importers, there is quite a bit of dispersion around the trend line, including some countries where large production runs appear to be associated with substantial economies of scale gains that outweigh terms of trade losses from exports (Malaysia). But for others (Indonesia), the terms of trade loss appears to outweigh any economy of scale gain, in that social surplus is estimated to be negative.

Finally considering both Figures together suggests that there are many importers and many exporters with similar estimated social surplus (between 0 and 0.5). Clearly net production (production less expenditure) as a proxy for international trade cannot be the whole story. The next investigation considers the role for variety in IT trade.

5. Variety and the Dispersion of Country Experience

For both Figures, the trend regression line shows the average social surplus for the set of countries in the Figure. Countries above the regression line have a calculated social surplus from IT production less expenditure greater than average (whether an importer or exporter), whereas those below the trend line have a calculated social surplus from their production and expenditures on IT hardware less than the average.

Earlier research on the role for institutions, and labor and product market flexibility found that countries with more rigid markets (such as the continental European economies) tended to have lower TFP growth associated with ICT; these economies lie below the regression line in Figure 4a. Countries that tended to have faster TFP growth from ICT investments lie above the regression trend line (for example Finland, the United States, and Australia). The social surplus calculation appears to map well in the diversity of country experiences in using ICT.

[18] Removing Malaysia from the sample changes the trend coefficient to 0.093, so does not alter the overall observation.

In Figure 4b, for exporters, countries such as Korea, Israel, China, Singapore, and Ireland are high TFP countries where calculated social surplus is more than the average among exporters IT. Other exporters (such as Thailand, Brazil, Philippines, Mexico), while still enjoying positive social surplus, are growing less quickly than the average of their peer group of exporters. For at least some of these countries, previous research points to difficulties with the infrastructural environment, which does not support domestic use of IT.

Besides institutional factors, market competition, and infrastructure, research indicated that variety could be an important factor relating to social surplus. How much can variety in IT trade explain the dispersion of country experience around trend?

5.1 Variety: Measurement and Country Experience

Variety can be measured in several ways; this paper uses the Herfindahl (H) index.[19] For each country, the value of 178 different varieties of IT exports and imports from the United Nations COMTRADE database are allocated to five larger groups based on the OECD categorization (Other ICT, Computers, Components, Telecommunication, Audio-visual). [20] For example, the category Components includes 62 different varieties of components. The Herfindahl index for Components for a country measures whether its export (import) trade flows are about equally distributed over all 62 of the individual varieties (Herfindahl close to 0) or whether one particular variety of export (import) accounts for nearly all of the trade (Herfindahl close to 1).[21]

What might the H index reveal about a country's pattern of trade? Hs close to 1 for one or more of the five categories suggests that imports (exports) of a particular IT variety accounts for nearly the whole value of trade in that category. Systematically high Hs in the Computer and Component categories may point to the country being part of the global value chain rather than having much production designed to satisfy domestic demand. Export Hs close to 1 might be associated with deleterious terms of trade, whereas import Hs close to 1 would be associated with positive terms of trade effects, especially if trade is concentrated in a few intermediate inputs.

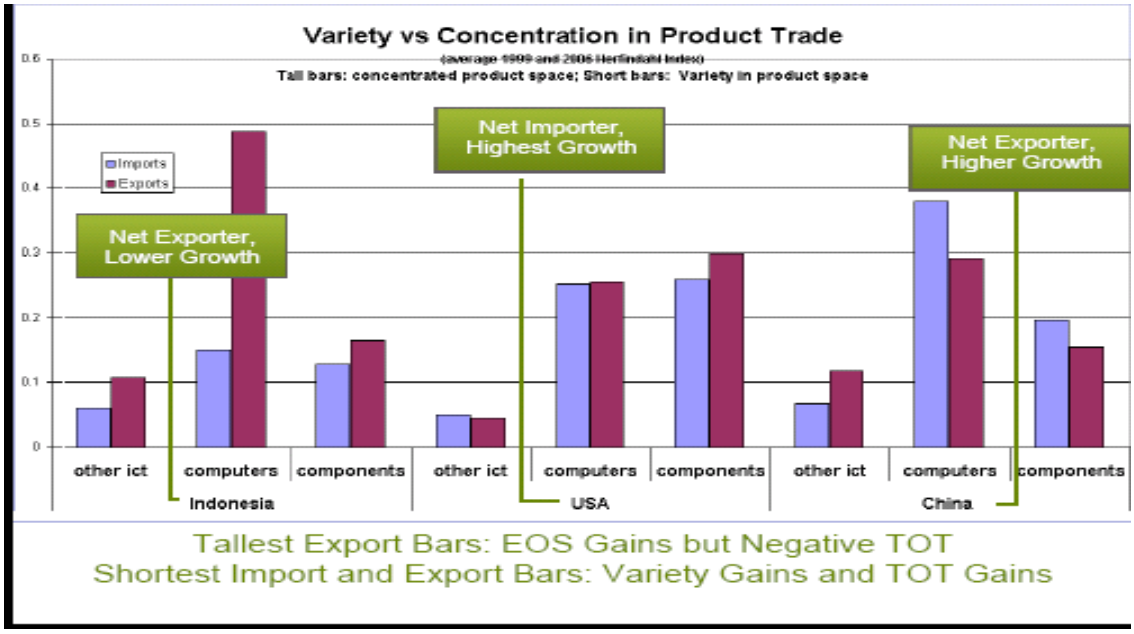
Systematically low Hs in the Other ICT and Audio-visual categories may be associated with a greater variety of products that have embedded ICT (such as medical devices, control instruments, and set-top boxes). Greater variety may support innovation in business process and workplace practices, in that customers are more likely to find products to meet their needs and that they can use to change business process and workplace practice.

[19] The Herfindahl index is often used in industrial-organization investigations to assess the extent of market competition among several firms, vis '4-firm concentration ratio'. Here we can use it to assess the extent to which a country imports or exports a wide variety of detailed products or is specialized in importing or exporting just a few products.
[20] The broad ICT categories correspond to OECD 2003b.
[21] For more details on the construction of the Herfindahl indexes, see Mann (2011).

Figure 5 below shows Herfindahl indexes for three countries with different patterns of trade and social surplus. Indonesia is an exporter with lower than average social surplus for exporters (lies below the trend line for exporters). It has a very high concentration of trade in Computer exports. With a concentrated export pattern, but lower than average social surplus suggests that economies of scale in production does not outweigh the terms of trade effect.

China is also an exporter, but with higher than average social surplus (lies above the trend line) for exporters. Although China's exports of Computers are somewhat concentrated, it has an even greater concentration in imports of Components. Therefore, China may achieve higher than average social surplus by importing and getting the benefits of the terms of trade on Components; then by producing at economies of scale for export.

The United States is an importer with higher than average social surplus (lies above the trend line) for importers. The U.S. has moderate concentration of both exports and imports in Computers and Components. Notably however, it has a lot of variety (low H) of both imports and exports of Other ICT products. On the import side, greater variety may meet more business needs and support TFP. On the export side, greater variety is consistent with some market power in trade, offsetting the otherwise deteriorating terms



of trade.

Figure 5: Country examples: Variety and Deviation from Average Social Surplus

A systematic assessment of how variety is related to the dispersion of countries around the mean and compared to their peers involves an econometric estimation. Table 3 reports on a simple regression relating the deviation of the country experience from average and the Herfindahl measures of variety.

The difference between the individual country data points and the trend regression lines in the previous charts represents the country-specific deviation from the average relationship for all the countries. Positive (negative) residuals represent countries above (below) the social surplus average, whether importers or exporters. Are these residuals related to variety in exports and imports of the five categories of ICT trade?

Table 3: Country Deviation from Trend line and Export and Import Concentration

Countries Below Average (negative residuals)

		Coefficients	Standard Error	t Stat
Import concentration 2006	Intercept	1.97848375	0.4783293	4.136238
	computers	-0.0680493	0.37851722	-0.17978
	components	-8.8013144	2.55014584	-3.4513
	telecoms	-1.36409183	0.71022729	-1.92064
	av	-0.41073959	0.77676283	-0.52878
Export concentration 2006	computers	0.23293815	0.47546042	0.489921
	components	3.38250904	1.34515425	2.514588
	telecoms	-0.15029666	0.3415916	-0.43999
	av	0.8211437	0.28915735	2.839782

Countries Above Average (positive residuals)

		Coefficients	Standard Error	t Stat
Import concentration 2006	Intercept	0.302610986	0.8974011	0.337208
	computers	0.082895698	1.4377481	0.057657
	components	-0.547320875	1.9650254	-0.27853
	telecoms	-0.447041594	1.2689741	-0.35229
	av	0.748854012	3.194853	0.234394
Export concentration 2006	computers	0.355216222	0.8466289	0.419565
	components	1.436379223	0.9121335	1.574747
	telecoms	0.449863745	0.6655635	0.675914
	av	-1.250264029	1.0623114	-1.17693

This simple evidence suggests that variety may help explain the situation facing countries of below average social surplus. High import concentration, particular of Components and Telecommunications reduce the negative residuals, which is consistent with the countries benefiting from terms of trade. On the other hand, high export concentration, particularly Components and Audio-visual increases the residuals, moves the country further away from the average social surplus. This suggests that the economies of scale do not outweigh terms of trade and variety. For countries with positive residuals –social surplus above average—variety in trade does not seem to matter.

6. Policy Implications

What are the implications of these findings for economic growth? First, being part of the global supply chain of IT production may be a jumping off point for higher growth. Countries that either do not produce much or consume much of IT seem to be the less well off in terms of social surplus and growth. Second, a growth strategy that focuses on production mainly for export in the international supply chain gives up the potential gains to growth from importing and producing domestically a wide variety of IT products. For most countries, a high variety of traded IT products (both exports and imports) is associated with higher TFP and therefore higher growth. This variety of IT products as used in the domestic economy is associated with more wide-spread diffusion of IT throughout the economy, and associated higher TFP, higher GDP per capita and growth.

So, a growth strategy based on information technology might start with being a part of the international supply chain, so as to gain economy of scale benefits, but then matures to import and produce the variety of products appropriate for domestic needs. A domestic business environment that is conducive to transformation of economic activities enhances the likelihood that this variety of IT products yields higher growth.

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