This chapter considers three channels through which globalization of information technology (IT) products may affect economic growth:

- **Terms of trade.** The fall in quality-adjusted prices of IT products favors IT consumers, so net importers (whose consumption exceeds production) experience faster economic growth. But given the fragmentation of IT production into a global supply chain, it is not so simple to measure terms of trade.

- **Economies of scale.** IT production exhibits important economies of scale. For example, 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.

- **Variety.** Availability of a wide variety of IT products is also 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. The variety of exports might further support growth to the extent that variety increases prices and profits.

Several empirical questions are relevant for policy makers: What are 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 policy makers 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 total factor productivity (TFP)?

The chapter explores some of the issues, research, and metrics that can better inform policy makers’ approach to these questions, as follows:

- **Measuring Economic Growth: Getting to the Social Surplus Concept** addresses measurement issues and describes a metric and apparatus—“social surplus”—with which to evaluate, in general terms, the relationships between production and consumption of a transformative innovation, and economywide productivity and growth.

- **Data and the Literature on IT and Economic Growth** presents an overview of patterns of IT production, consumption, and trade and reviews the literature on the relationship between IT and growth.

- **International IT Trade and the Social Surplus Measure of Economic Growth** takes the social surplus apparatus to the data on IT production, consumption, and trade to consider the relative importance of economies of scale, variety, and terms of trade for economic well-being and as foundations for growth.

- **Variety and the Dispersion of Country Experience** discusses the correlation of social surplus to the diversity of countries’ use of IT and thereby to economic growth relative to peer IT-exporting or IT-importing economies. The analysis suggests that gains to variety in consumption can outweigh gains from economies of scale in production.

- **Policy Implications** sums up the findings’ implications for an IT-based economic growth strategy.
Measuring Economic Growth: Getting to the Social Surplus Concept

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.

Productivity Measures: Labor versus TFP

Labor productivity is output per unit of labor input and is often a key measure of the foundations for economic growth. Increased labor productivity can be achieved without innovation but 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 (also called 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—observable as new products, changes in business processes, or new workplace practices. Increased TFP also implies increased growth in the sense that the economy can produce more output to allocate toward final demand.

GDP versus GNI and the Role for Terms of Trade and TFP

Gross domestic product (GDP) and GDP per capita are standard measures of economic performance and growth. They incorporate increases in resources and 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, investment, and 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 a 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 domestic residents can enjoy.\(^1\) Similarly, if an economy has a structural balance of payments surplus, GDP overstates the extent to which domestic residents enjoy the fruits of economic growth.\(^2\)

Trends in the terms of trade are relevant from the standpoint not only of purchasing power but also of measuring productivity growth. Specifically, there is a mathematical isomorphism between changes in the terms of trade and changes in TFP: an improvement in the terms of trade is equivalent to an innovation that increases TFP and economic growth.\(^3\)

**Social Surplus, 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 (Bayoumi and Haacker 2002, 11–12; Feenstra et al. 2007; Kohli 2004, 2006). From the final consumer’s standpoint, 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 7.1 shows an example of the social surplus apparatus for a transformative technology.

As figure 7.1 illustrates, Social surplus \((A + B + C)\) is larger under the following conditions:

- Higher income elasticity of demand for transformative technology (TT)
- Higher price elasticity of demand for TT
• Bigger fall in TT price
• Larger initial TT expenditure
• More TT used as intermediates and TT externalities.

The next section reviews the empirical evidence underpinning the facts of IT globalization and the assertions that diffusion of IT products enhances TFP and economic growth. Later, “International IT Trade and the Social Surplus Measure of Economic Growth” calculates social surplus for a set of countries and considers (a) the relationship between social surplus and the extent to which the economy may gain through direct demand for IT, and (b) how the economy may gain through indirect demand for IT.

**Data and the Literature on IT and Economic Growth**

There is a vast literature on the relationship between IT and measures of economic growth. This paper highlights a small subset of the literature that focuses, first, on the relationship between economies of scale in...
IT production and economic growth and, second, on diffusion of variety of IT and economic growth. To give a frame of reference for the literature, we start with some observations based on data on the globalization of IT production and trade. The data have bearing on the issues of economies of scale and variety of IT products in international trade.

**Changing Patterns of International Trade and Domestic Expenditure**

That the IT industries are greatly globalized in production, investment, and cross-border trade goes without saying. The Organisation for Economic Co-operation and Development’s (OECD) *Information Technology Outlook* addresses and quantifies numerous measures of the globalization of the IT industry, for both goods and services. Additional assessments, predominantly for emerging markets and developing economies, can be found in the *Information Economy Report* and the *World Investment Report*, both published by the United Nations Conference on Trade and Development (UNCTAD).

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. In addition, an increase in exporters’ revealed comparative advantage for information and communication technology (ICT) goods during the 1990s (OECD 2008, 94–95) also points to some concentration of global production of specific parts and components, even as the production process of a wider variety of “final” ICT goods remains highly fragmented.

**IT Exporters.** Data on the IT goods trade, as table 7.1 shows, exhibit both rapid changes in ranking among the top exporters and importers and changes in trade concentration. The bottom line is that the sum of China and Hong Kong SAR, China, exploded from 2 percent of global exports (ranked 14th) in 1990 to 15 percent of global exports (ranked 1st) in 2004. On the import side, China and Hong Kong SAR, China, moved from 9th-ranked, with 4 percent of global imports, to top-ranked with 20 percent of global imports.
Table 7.1 Global IT Trade Patterns, by Economy, 1990–2004

<table>
<thead>
<tr>
<th>Rank</th>
<th>Economy</th>
<th>Share of world trade (percent)</th>
<th>Cumulative share (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
<td>a. 1990</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exports</td>
<td>Japan</td>
<td>20.4</td>
<td>20.4</td>
</tr>
<tr>
<td></td>
<td>United States</td>
<td>19.3</td>
<td>39.7</td>
</tr>
<tr>
<td></td>
<td>United Kingdom</td>
<td>7.7</td>
<td>47.4</td>
</tr>
<tr>
<td></td>
<td>Germany, Federal Rep.</td>
<td>7.4</td>
<td>54.8</td>
</tr>
<tr>
<td></td>
<td>Singapore</td>
<td>6.7</td>
<td>61.5</td>
</tr>
<tr>
<td></td>
<td>China and Hong Kong SAR, China</td>
<td>1.7</td>
<td>n.a.</td>
</tr>
<tr>
<td>Imports</td>
<td>United States</td>
<td>20.6</td>
<td>20.6</td>
</tr>
<tr>
<td></td>
<td>Germany, Federal Rep.</td>
<td>9.7</td>
<td>30.3</td>
</tr>
<tr>
<td></td>
<td>United Kingdom</td>
<td>9.0</td>
<td>39.3</td>
</tr>
<tr>
<td></td>
<td>France</td>
<td>6.5</td>
<td>45.8</td>
</tr>
<tr>
<td></td>
<td>Italy</td>
<td>4.5</td>
<td>50.3</td>
</tr>
<tr>
<td></td>
<td>China and Hong Kong SAR, China</td>
<td>3.9</td>
<td>n.a.</td>
</tr>
<tr>
<td>b. 2000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exports</td>
<td>United States</td>
<td>17.0</td>
<td>17.0</td>
</tr>
<tr>
<td></td>
<td>Japan</td>
<td>14.1</td>
<td>31.1</td>
</tr>
<tr>
<td></td>
<td>Singapore</td>
<td>9.8</td>
<td>40.9</td>
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<tr>
<td></td>
<td>Korea, Rep.</td>
<td>6.6</td>
<td>47.5</td>
</tr>
<tr>
<td></td>
<td>Taiwan, China</td>
<td>6.4</td>
<td>53.9</td>
</tr>
<tr>
<td></td>
<td>China and Hong Kong SAR, China</td>
<td>4.2</td>
<td>n.a.</td>
</tr>
<tr>
<td>Imports</td>
<td>United States</td>
<td>20.3</td>
<td>20.3</td>
</tr>
<tr>
<td></td>
<td>China and Hong Kong SAR, China</td>
<td>10.0</td>
<td>30.3</td>
</tr>
<tr>
<td></td>
<td>Japan</td>
<td>6.7</td>
<td>37.0</td>
</tr>
<tr>
<td></td>
<td>Singapore</td>
<td>6.7</td>
<td>43.7</td>
</tr>
<tr>
<td></td>
<td>Germany</td>
<td>5.9</td>
<td>49.6</td>
</tr>
</tbody>
</table>

(continued next page)
There were other changes in the trade landscape, even if not so dramatic. Between 1990 and 2004, the cumulative share of the top three exporters fell from 47 percent to 35 percent, suggesting less trade concentration.

The top three IT-exporting economies also changed over the 1990–2004 period: Japan dropped from being the top exporter (with 20 percent of world exports) in 1990 to fourth (with 8 percent) in 2004. China and Hong Kong SAR, China, rose from 14th (with 1.7 percent of world exports) in 1990 to first (with 15 percent) in 2004. The United States remained the second-largest exporter (with 19 percent of world exports) in 1990 but with only 11 percent in 2004. The United Kingdom was the third-largest exporter in 1990 but dropped to 10th in 2004. Singapore rose from fifth-largest in 1990 to third-largest in 2004.

**IT Importers.** On the import side, concentration has changed little, but the rankings have changed. The top-three importers accounted for about 40 percent of world imports from 1990 through 2004. The United
States was the top-ranked importer in 1990, accounting for about 20 percent of world imports—about the same as what China and Hong Kong SAR, China, accounted for with its top ranking in 2004. China and Hong Kong SAR, China, doubled its share of global imports from only 4 percent of imports in 1990 to 10 percent by 2000, and then doubled its share again to reach 20 percent in 2004. The United States slipped to second by 2004 with 15 percent of world imports. Among the other top-ranking importers, Germany, Japan, and Singapore rounded out the top-five list in both 2000 and 2004, albeit in changing order.

**IT Expenditures.** An interesting question is whether countries that rank highly in global trade also rank highly in domestic expenditure on IT. A quick look at the data in table 7.2 indicates that deep involvement in global production and international trade in IT does not necessarily correlate with a country’s domestic spending on IT.

For example, the United States accounted for 45 percent of global expenditure on IT in 2000, shrinking to 36 percent by 2008. Both shares, though, were substantially larger than the U.S. share of global IT trade. Germany’s and Japan’s shares of global IT trade, however, were somewhat closer to their shares of domestic IT expenditure. China and Hong Kong SAR, China, quadrupled its share of global expenditure between 2000 and 2008, ranking sixth in global expenditure by 2008, but its share of expenditure remained quite small relative to that economy’s importance in global trade.

If an economy’s share of world trade and its share of global expenditure were the same, it would suggest a balanced expansion path for that economy overall. When economies have higher shares of global trade than of global expenditure, that suggests that IT is relatively more important as a production platform for growth through international trade than through domestic use. On the other hand, if the share of expenditure is greater than the share of trade, that suggests that domestic business use of IT in the economy is the basis for growth.

**Gains from Producing IT versus Using IT**

We turn now to a review of selected empirical studies on the relationship between IT and economic growth. The research agenda started
with a focus on how the ICT-producing sector generates economic growth though high estimated TFP and economies of scale in production. Van Ark (2005), using 1979–2002 data, shows that TFP in the ICT-producing sector is higher than it is in other sectors: 8 percent in the ICT-producing sector versus 3 percent in the ICT-using sectors. Chun and Nadiri (2008) find that in the United States (using 1978–99
data), economies of scale in ICT production account for 30 percent of TFP in the ICT-producing sector.

From a policy-making perspective, however, 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 small country must produce primarily a narrow set of products for export because domestic demand is unlikely to absorb all that is produced. Globalization of ICT production—and the rising share of the production complex of China and Hong Kong SAR, 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 versus ICT-using sectors reveals that TFP in ICT-using industries increased 250 percent versus only 30 percent in ICT-producing industries (comparing data from 1979–95 and 1995–2002, respectively). Mun and Nadiri’s (2002) research using U.S. data shows that networked IT deployed in an ICT-using sector (particularly in services) 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 looked 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 (Gust and Marquez 2000; OECD 2003b; and van Ark, Inklaar, and McGuckin 2003 focus on continental Europe). If businesses cannot (or have no incentive to) change product mix or change what workers do, then buying IT is just an additional cost of doing business rather than an enhancement to the business (see case examples in Mann, Eckert, and Knight 2000).
Further, if ICT investment takes place in a business environment lacking in strong international competition, productivity growth also lags (Shih, Kraemer, and Dedrick 2007).

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 higher productivity and growth (Dewan and Kraemer 2000; Pohjola 2001; Sciadas 2005; Seo and Lee 2006).

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 percent of the difference in measured TFP across countries. Feenstra and Kee (2008) 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 percent of TFP growth in developing countries (Broda, Greenfield, and Weinstein 2006). The way this works is that, with an insufficient variety of ICT products, the business community may find only poor matches to its needs and would use less ICT, resulting in lower productivity and growth.

In sum, even though TFP is higher in the ICT-producing sector and economies of scale in production are quite important, the results of research on the relationship between ICT and economic growth increasingly point away from production of ICT and more toward how ICT is used by businesses in an economy and what features of the economy are most conducive to that use. 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.

International IT Trade and the Social Surplus
Measure of Economic Growth

Despite the obvious relationships, little of the literature on IT and growth addresses the nexus of international IT trade 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 IT trade.

With increased globalization of production and international trade, the decline in quality-adjusted prices of IT products has different implications for producers of exported IT versus consumers of imported IT. But this fragmentation of production around the world enables some countries to establish significant economies of scale in production of 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?

**International IT Trade 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—resulting in gains to social surplus, productivity, and economic growth. Yet special economic zones in some countries focus on production for export rather than domestic use.

Whereas production and export of IT products obviously should not directly harm an economy,8 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 versus 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 versus an IT buyer (or falling somewhere in between, as do most economies). The first step estimates social surplus for a set of countries. The second step uses the net of production and expenditure as a measure of international IT trade. The final step considers why countries differ from each other beyond being net producers (exporters) or net consumers (importers) of IT.
Figure 7.2 sets out the hypotheses, based on the previous literature, concerning the roles of the following factors:

- **Terms of trade.** 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 dash line.

- **Economies of scale.** However, economies of scale favor high-volume IT producers, who are probably also exporters. TFP 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 solid black line up, creating a U-shaped relationship between social surplus and the production–expenditure (trade) balance.

- **Variety.** Research suggests that greater variety of IT products, including imports, used by business supports TFP and social surplus.

**Figure 7.2 Growth and International IT Trade: The Hypotheses**

Source: Author.

Note: TFP = total factor productivity. Social surplus is the calculation of overall economic gain from the falling prices associated with an innovation.
A greater variety of exports likely achieves relatively higher prices (fewer of the products are low-margin commodities), which offsets the otherwise deleterious terms-of-trade effect for exporters. Therefore, all else equal, increased variety would tend to shift the U-shaped curve further upward.

Given this set of hypotheses, what do the data reveal?

**Patterns of IT Trade and Social Surplus: The Evidence**

The first step is to calculate social surplus. Following the previous discussion in the *Measuring Economic Growth* section, the main ingredients to this calculation are data for each economy's (a) real GDP, (b) real IT prices, (c) real production of IT, and (d) real domestic expenditure on IT. The estimated price and income elasticities of demand for IT also are needed.9

Social surplus is calculated as the average for 2000–07 for 36 economies, as shown in figure 7.3. The figure shows the relationship between

**Figure 7.3 Growth and International Trade in IT: The Calculations**

![Graph showing the relationship between economic growth and net IT trade as a percentage of GDP.](image)

Source: Mann 2009.
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 2003–06, averaged). The linear segments show the linear trend (regression) relationship for importers taken alone and for exporters taken alone.

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

Figure 7.4 shows the two sides of the previous diagram along with more economy-specific 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.

**IT Importers.** First, consider the importers (see figure 7.4, panel a) to be those economies where IT expenditure exceeds IT production. For these economies, falling IT prices increase social surplus because more consumers accumulate the benefits of falling IT prices, both directly and indirectly, as IT diffuses through the economy.

The trend line in figure 7.4, panel a, reveals the positive relationship between social surplus and imports of IT: the larger the (negative) gap between production and expenditure on IT hardware (for example, imports), the greater the increase in social surplus (for example, accumulated gain to buyers from declining IT hardware prices). The trend relationship is somewhat greater than unity (–1.5), indicating that a 1 percent increase in IT imports (production less expenditure) is associated with a 1.5 percent 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 (2002) 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
(for example, a steeper slope of −1.5 versus −0.9). This implies that the translation of IT imports into social surplus, productivity, and economic growth has been stronger in the recent decade than during the 1990s. This is a bit surprising because the quality-adjusted decline in IT prices actually slowed in the 2000s compared with the 1990s (from
about 11 percent per year to about 8.5 percent per year). That the relationship is strengthening suggests that more economies are getting greater social surplus gains from their IT expenditures and imports. In other words, economies on average are experiencing greater changes in products, processes, and practices by using IT over the past decade than during the dot-com decade.

Second, around the trend line is quite a dispersion of experience of individual economies. Some of the dispersion could be due to greater variety of imports or IT expenditures, which accentuates social surplus gains. Some dispersion could also be due to institutional and business environment factors that affect the relationship between IT diffusion and productivity growth, as discussed in the literature. The next section will address these points further.

**IT Exporters.** Now consider the exporters, where IT production exceeds IT expenditure (see figure 7.4, panel b). For these economies, two forces directly influence the underlying IT prices associated with the social surplus calculation. On the one hand, the terms of trade should worsen for exporters of IT hardware, 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 there is virtually no relationship between being an exporter and social surplus, which was also the case using data from the 1990s. However, the observation that the trend line cuts the y-axis at around 0.76 percent indicates that an economy 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 negative relationship between social surplus and just the terms of trade is not, on average, supported by the data for exporters. As suspected, it appears that economies of scale do offset the pure terms-of-trade effect.

As was the case for importers, for exporters as well there is quite a bit of dispersion around the trend line, including some economies where a high production share of GDP 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 economies-of-scale gain, in that social surplus for Indonesia is estimated to be negative.

Finally, considering both panels a and b of figure 7.4 together suggests that many importers and exporters have 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 section considers the role for variety in IT trade.

**Variety and the Dispersion of Country Experience**

In both panels of figure 7.4, the trend regression line shows the average social surplus and trade relationship for a particular set of economies. Those above the regression line have a greater-than-average calculated social surplus from IT production less expenditure (whether an importer or exporter), whereas those below the trend line have a less-than-average calculated social surplus from their production and expenditures on IT.

Earlier research on the roles for institutions and for 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 7.4, panel a. Countries that tended to have faster TFP growth from ICT investments lie above the regression trend line (for example, Australia, Finland, and the United States). The social surplus calculation appears to map well to the diversity of country experiences in using ICT.

For exporters (see figure 7.4, panel b), countries such as China, Ireland, Israel, the Republic of Korea, and Singapore are high-TFP countries where calculated social surplus is more than the average among IT exporters. Other exporters (such as Brazil, Mexico, the Philippines, and Thailand), while still enjoying positive social surplus, are growing less quickly than the average within their peer group of exporters. For at least some of these countries, previous research points to difficulties with the infrastructural environment, which is less supportive of domestic use of IT.

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

**Variety: Measurement and Country Experience**

Variety can be measured in several ways. This work uses the Herfindahl (H) index. For each country, the value of 178 varieties of IT exports and imports from the United Nations Comtrade database are allocated to five larger groups based on the OECD (2003a) categorization: other ICT, computers, components, telecommunication, and audio-visual. For example, the components category includes 62 varieties of components. The Herfindahl index for components measures whether a country’s export (import) trade flows are about equally distributed among all 62 individual varieties (H close to 0) or whether one particular variety of export (import) accounts for nearly all of the trade (H close to 1).

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 suggest that imports (exports) of a particular IT variety account 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 processes and workplace practices in that business consumers are more likely to find products to meet their needs and to use in order to change business processes and workplace practices.

Figure 7.5 shows Herfindahl indexes for three countries with different patterns of trade and social surplus:

- **Indonesia** is an exporter with lower-than-average social surplus (lying below the trend line) for exporters and a high concentration of trade in computer exports. A concentrated export pattern with
Figure 7.5 Variety vs. Concentration in Product Trade, Selected Countries
average of 1999 and 2006 Herfindahl indexes

Source: Author.

Note: EOS = economies of scale. TOT = terms of trade. ICT = information and communication technology. Overall, tall bars designate concentrated product space; short bars designate variety in product space. The tallest export bars designate EOS gains but negative TOT. The shortest import and export bars designate variety gains and TOT gains.
lower-than-average social surplus suggests that economies of scale in production do not outweigh the terms-of-trade effect.

- **China** is also an exporter but with higher-than-average social surplus (lying above the trend line) for exporters. Although China’s computer exports are somewhat concentrated, it has an even greater concentration of component imports. Therefore, China is more likely to achieve higher-than-average social surplus by importing and getting the benefits of the terms of trade on components than by producing at economies of scale for export.

- **The United States** is an importer with higher-than-average social surplus (lying above the trend line) for importers and a 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 associated with an ability to price above cost, therefore offsetting the otherwise deteriorating terms of trade.

A systematic assessment of how variety is related to the dispersion of countries around the mean, thus a comparison with their peers, involves an econometric estimation. Table 7.3 reports on a simple regression relating the deviation of countries’ experience from the average of their peer group 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 measured. 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?

This simple evidence regarding the role for variety is stronger for countries that have negative residuals—those with below-average social surplus, whether as exporters or importers. On the import side, a high import concentration (particularly of components and telecommunications) reduces the negative residuals, which is consistent with the countries benefiting from terms of trade. However, a high export
Table 7.3 Country Deviation from Trend Line and Export and Import Concentration

<table>
<thead>
<tr>
<th></th>
<th>a. Countries below average (negative residuals)</th>
<th></th>
<th>b. Countries above average (positive residuals)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficients</td>
<td>Standard error</td>
<td>T-stat</td>
</tr>
<tr>
<td>Intercept</td>
<td>1.97848375</td>
<td>0.47832930</td>
<td>4.136238</td>
</tr>
<tr>
<td>Import concentration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computers</td>
<td>−0.06804930</td>
<td>0.37851722</td>
<td>−0.179780</td>
</tr>
<tr>
<td>Components</td>
<td>−8.8031440</td>
<td>2.55014584</td>
<td>−3.451300</td>
</tr>
<tr>
<td>Telecoms</td>
<td>−1.36409183</td>
<td>0.71022729</td>
<td>−1.920640</td>
</tr>
<tr>
<td>Audio-visual</td>
<td>−0.41073959</td>
<td>0.77676283</td>
<td>−0.528780</td>
</tr>
<tr>
<td>Export concentration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computers</td>
<td>0.23293815</td>
<td>0.47546042</td>
<td>0.489921</td>
</tr>
<tr>
<td>Components</td>
<td>3.38250904</td>
<td>1.34515425</td>
<td>2.514588</td>
</tr>
<tr>
<td>Telecoms</td>
<td>−0.15029666</td>
<td>0.34159160</td>
<td>−0.439990</td>
</tr>
<tr>
<td>Audio-visual</td>
<td>0.82114370</td>
<td>0.28915735</td>
<td>2.839782</td>
</tr>
</tbody>
</table>

Source: Author.
concentration (particularly components and audio-visual) increases the residuals, moving the country further away from the average social surplus. This finding suggests that the economies of scale do not outweigh terms of trade and variety. For countries with positive residuals (social surplus above average), the extent of variety in trade does not seem to be an important factor in explaining how a country differs from its peers. This may be because many of these countries already have a relatively high variety of both imports and exports.

**Policy Implications**

What are the implications of these findings for economic growth?

First, becoming part of the global supply chain of IT production to gain economies of scale may be a jumping-off point for higher growth. Countries that neither produce nor consume much IT are the least 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 that come from importing, consuming, or producing domestically a wide variety of IT products. Therefore, 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-widespread diffusion of IT throughout the economy—and with higher TFP, higher GDP per capita, and growth.

Therefore, an IT-based growth strategy might start with being a part of the international supply chain to gain economy-of-scale benefits and later mature to import and produce the variety of products appropriate for domestic needs. Appropriate infrastructure and institutions—and a domestic business environment that is conducive to transformation of economic activities—enhances the likelihood that this variety of IT products yields higher growth.

**Notes**

1. See United Nations (2008) for general discussion of the terms-of-trade effect on GDP versus GNI. See also Feenstra et al. (2007) for a further discussion of real production versus real expenditure measures and their implications for welfare

2. The balance of payments surplus presumably is invested and thus there is an intertemporal trade-off between the generation today and future generations.


4. 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.

5. 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 discussions in the Information Technology Outlook (OECD 2008, 87) and Information Technology Report (UNCTAD 2007).

6. See Mann (2006, 33)—on apparent concentration of production by U.S. multinationals in low-cost locations—and Reed Electronics Research data.

7. Herein, much of the extant research includes telecommunications (C) as well as information technology (IT) products, thus ICT.

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

9. Mann (2011) gives more details on the construction of the data and calculation of each country’s social surplus. Among important points in the construction of social surplus: Calculations consider only IT hardware, not communications and not software. Communications is not addressed primarily because many countries still have publicly owned communications networks, making market forces less important in production, spending, and pricing decisions. Data on international trade in software products and associated prices are not available. Moreover, calculations in Bayoumi and Haacker (2002) show, for the time period of their study, that the main contributor to social surplus is the price and expenditure dynamic for IT hardware.

10. The calculations for net price decline for each economy incorporate domestic price changes and exchange rate changes, but the dominant feature driving the data is the IT price decline in the U.S. data.

11. Removing Malaysia from the sample changes the trend coefficient to 0.093, so it does not alter the overall observation.

12. The Herfindahl index is often used in industrial-organization investigations to assess the extent of market competition among several firms—for example, “four-firm concentration ratio.” Here one 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. For more details on the construction of the Herfindahl indexes, see Mann (2011).
References


Economics and International Business School, Brandeis University, Waltham, Mass.


Reed Electronics Research (database). RER (Reed Electronics Research), Oxon, U.K. http://www.rer.co.uk/.


