and lowers the average production cost of each firm. The downward shift in curve C to curve C' leads to new long-run equilibrium point E', $P = AC = \$2$ and $N = 400$, as compared with original equilibrium point E (with $P = \$3$ and $AC = \$3$). Note that the increase in total industry sales does not affect the P curve (i.e., the P curve does not shift).

6.5 Trade Based on Dynamic Technological Differences

Apart from differences in the relative availability of labor, capital, and natural resources (stressed by the Heckscher–Ohlin theory) and the existence of economies of scale and product differentiation, dynamic changes in technology among nations can be a separate determinant of international trade. These are examined by the technological gap and product cycle models. Since time is involved in a fundamental way in both of these models, they can be regarded as dynamic extensions of the static H–O model.

6.5A Technological Gap and Product Cycle Models

According to the technological gap model sketched by *Posner* in 1961, a great deal of the trade among industrialized countries is based on the introduction of new products and new production processes. These give the innovating firm and nation a *temporary* monopoly in the world market. Such a temporary monopoly is often based on patents and copyrights, which are granted to stimulate the flow of inventions.

As the most technologically advanced nation, the United States exports a large number of new high-technology products. However, as foreign producers acquire the new technology, they eventually are able to conquer markets abroad, and even the U.S. market for the product, because of their lower labor costs. In the meantime, U.S. producers may have introduced still newer products and production processes and may be able to export these products based on the new technological gap established. A shortcoming of this model, however, is that it does not explain the size of technological gaps and does not explore the reason that technological gaps arise or exactly how they are eliminated over time.

A generalization and extension of the technological gap model is the product cycle model, which was fully developed by *Vernon* in 1966. According to this model, when a new product is introduced, it usually requires highly skilled labor to produce. As the product matures and acquires mass acceptance, it becomes standardized; it can then be produced by mass production techniques and less skilled labor. Therefore, comparative advantage in the product shifts from the advanced nation that originally introduced it to less advanced nations, where labor is relatively cheaper. This may be accompanied by foreign direct investments from the innovating nation to nations with cheaper labor.

Vernon also pointed out that high-income and labor-saving products are most likely to be introduced in rich nations because (1) the opportunities for doing so are greatest there, (2) the development of these new products requires proximity to markets so as to benefit from consumer feedback in modifying the product, and (3) there is a need to provide service. While the technological gap model emphasizes the time lag in the *imitation* process, the product cycle model stresses the *standardization* process. According to these models, the most highly industrialized economies are expected to export nonstandardized products embodying new and more advanced technologies and import products embodying old or less advanced technologies.

A classic example of the product cycle model is provided by the experience of U.S. and Japanese radio manufacturers since World War II. Immediately after the war, U.S. firms dominated the international market for radios, based on vacuum tubes developed in the United States. However, within a few years, Japan was able to capture a large share of the market by copying U.S. technology and utilizing cheaper labor. The United States recaptured technological leadership with the development of transistors. But, once again, in a few short years, Japan imitated the technology and was able to undersell the United States. Subsequently, the United States reacquired its ability to compete successfully with Japan by introducing printed circuits. It remains to be seen whether this latest technology will finally result in radios being labor or capital intensive and whether the United States will be able to stay in the market—or whether both the United States and Japan will eventually be displaced by still cheaper producers in such nations as Korea and Singapore.

In a 1967 study, *Gruber, Mehta, and Vernon* found a strong correlation between expenditures on research and development (R&D) and export performance. The authors took expenditures on research and development as a proxy for the *temporary* comparative advantage that firms and nations acquire in new products and new production processes. As such, these results tend to support both the technological gap model and the closely related product cycle model. We will see in Chapter 7 that the technological lead of the United States based on R&D has now almost disappeared with respect to Europe and Japan and has sharply narrowed with respect to some of the most advanced emerging markets such as China.

Note that trade in these models is originally based on new technology developed by the relatively abundant factors in industrialized nations (such as highly skilled labor and expenditures on research and development). Subsequently, through imitation and product standardization, less developed nations gain a comparative advantage based on their relatively cheaper labor. As such, trade can be said to be based on changes in relative factor abundance (technology) among nations over time. Therefore, the technological gap and product cycle models can be regarded as extensions of the basic H–O model into a technologically dynamic world, rather than as alternative trade models. In short, the product cycle model tries to explain *dynamic* comparative advantage for new products and new production processes, as opposed to the *basic* H–O model, which explains *static* comparative advantage. We return to this source of growth and change in comparative advantage over time in the next chapter.

6.5B Illustration of the Product Cycle Model

The product cycle model can be visualized with Figure 6.4, which identifies five different stages in the life cycle of a product (according to one version of the model) from the point of view of the innovating and the imitating country. In stage I, or new-product phase (referring to time *OA* on the horizontal axis), the product (at this time a specialty) is produced and consumed only in the innovating country. In stage II, or product-growth phase (time *AB*), production is perfected in the innovating country and increases rapidly to accommodate rising demand at home and abroad. At this stage, there is not yet any foreign production of the product, so that the innovating country has a monopoly in both the home and export markets.

In stage III, or product-maturity phase (time *BC*), the product becomes standardized, and the innovating firm may find it profitable to license other domestic and foreign firms to also manufacture the product. Thus, the imitating country starts producing the product

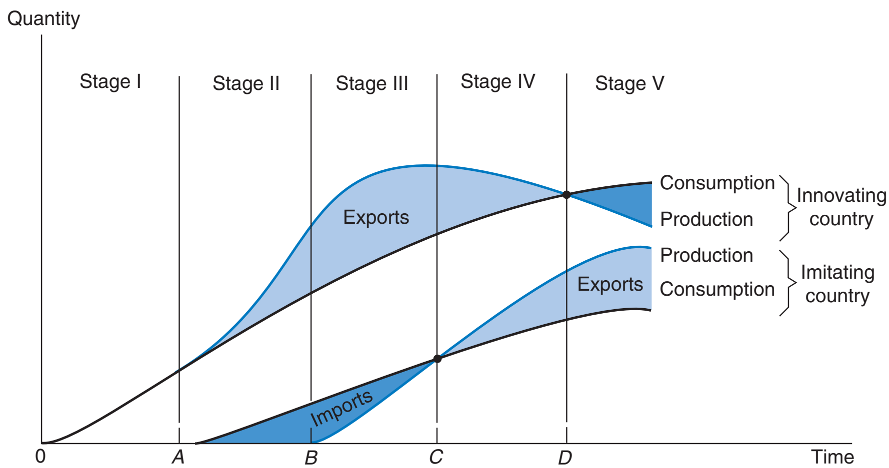

FIGURE 6.4. The Product Cycle Model.
In stage I (time *OA*), the product is produced and consumed only in the innovating country. In stage II *(AB)*, production is perfected in the innovating country and increases rapidly to accommodate rising demand at home and abroad. In stage III *(BC)*, the product becomes standardized and the imitating country starts producing the product for domestic consumption. In stage IV *(CD)*, the imitating country starts underselling the innovating country in third markets, and in stage V (past point *D*) in the latter's market as well.

for domestic consumption. In stage IV (time *CD*), the imitating country, facing lower labor and other costs now that the product has become standardized and no longer requires development and engineering skills, begins to undersell the innovating country in third markets, and production of the product in the innovating country declines. Brand competition now gives way to price competition. Finally, in stage V (i.e., past point *D*), the imitating country starts underselling the innovating country in the latter's market as well, and production of the product in the innovating country declines rapidly or collapses. Stages IV and V are often referred to as the product-decline stage. Technological diffusion, standardization, and lower costs abroad thus bring the end of the life cycle for the product. It is now time for the innovating country to concentrate attention on new technological innovations and to introduce new products.

Examples of products that seem to have gone through such product cycles are radios, stainless steel, razor blades, television sets, and semiconductors. In recent years, the diffusion lag of new technologies has shortened considerably, so that we have witnessed a time compression of the product life cycle. That is, the time from the introduction of a new product in the innovating country to the time when the imitating country displaces the innovating country in third markets and in the innovating country itself has become shorter and shorter. This may spell trouble for a country like the United States, which relies on new technologies and new products to remain internationally competitive. The benefits that the United States can reap from the new technologies and new products that it introduces are ever more quickly copied by other countries, especially Japan. In fact, Steven Jobs' Apple created the iPad but it outsourced all of its production! The old saying "The United States must run faster and faster simply to avoid falling behind" is very appropriate here. By turning out new products and technologies very rapidly, however, the United States is ranked as the most competitive economy in the world (see Case Study 6-7).

CASE STUDY 6-7 The United States as the Most Competitive Economy

Table 6.5 shows the 20 top-ranked nations in international competitiveness in 2011, as measured by the Switzerland-based Institute for Management Development (IMD). *International competitiveness* was defined as the ability of a country or company to generate more wealth for its people than its competitors in world markets. International competitiveness was calculated as the weighted average of more than 300 competitiveness criteria grouped into four large categories: (1) economic performance (macroeconomic evaluation of the domestic economy); (2) government performance (extent to which government policies are conducive to competitiveness); (3) business efficiency (extent to which enterprises perform in an innovative and profitable way); and (4) infrastructure (extent to which basic technological, scientific, and human resources meet the needs of business).

As Table 6.5 shows, Hong Kong occupies the top position, followed by the United States, Switzerland, Singapore, Sweden, and Canada. Germany is ninth and the United Kingdom is eighteenth. Of the G-7 countries, Japan is twenty-seventh, France is twenty-ninth, and Italy is fortieth.

TABLE 6.5. International Competitiveness Rankings in 2012

Rank	Country	Rank	Country
1	Hong Kong	11	Netherlands
2	United States	12	Luxembourg
3	Switzerland	13	Denmark
4	Singapore	14	Malaysia
5	Sweden	15	Australia
6	Canada	16	United Arab Rep.
7	Taiwan	17	Finland
8	Norway	18	United Kingdom
9	Germany	19	Israel
10	Qatar	20	Ireland

Source: Institute for Management Development, 2012.

6.6 Costs of Transportation, Environmental Standards, and International Trade

So far we have assumed that costs of transportation are zero (assumption 9 in Section 5.2). In this section, we relax this assumption. We will see that costs of transportation affect international trade directly by affecting the price of the traded commodity in the exporting and importing countries, and indirectly by affecting the international location of production and industry. We also examine these two effects as well as the effect of environmental pollution on the location of industry and international trade.

6.6A Costs of Transportation and Nontraded Commodities

Costs of transportation include freight charges, warehousing costs, costs of loading and unloading, insurance premiums, and interest charges while goods are in transit. We will use