Chapter 6

Intermediate Input Trade and Offshoring

If you just had a cup of coffee, you are not alone. Every day, consumers around the world drink an estimated 1.5 billion cups of coffee. Three-hundred million cups are served daily just in the United States. In many regards, coffee is today's most ubiquitous global good. How does the coffee from distant farms end up in your cup? How does the global supply chain for coffee connect, and what does its organization imply for the distribution of the gains from the trade and people's incomes?

Let's start with the coffee growers. Millions of farmers, mostly in developing countries, prepare the crop and harvest the beans. Coffee is the third-most traded agricultural commodity after wheat and corn.[1] The farmers' incomes and those of many economies depend on the price of the beans, which is mainly determined on commodity exchanges in London and New York.

Global traders acquire the beans from farmers or their cooperatives at the world market price set on the exchanges. The traders then screen, sort, and store the raw beans, and sell them on to roasters. The roasters finally blend, roast, grind and package the coffee, mostly in developed countries. Roughly three-quarters of the value added in your cup accrues between a seaport near you and the retail shelve at your supermarket, or the espresso machine at your favorite café.

Learning Objectives

After reading this chapter you should be able to:

LO1 Explain how the trade in intermediate goods alters the assumptions of classic trade theory.

LO2 Elaborate how production stages can be ranked by their skill intensity. Then explain how a fall in the costs of offshoring leads to shifts of production stages across countries and affects income inequality within economies.

LO3 Describe how tasks can be ranked by contracting costs, demonstrate why cost savings arise when workers abroad perform certain tasks, and analyze what a drop in average contracting costs implies for income inequality within economies.

LO4 Present examples of global supply arrangements and assess their organization.

[1] For decades after the Second World War coffee trade was second only to trade in the global economy's other main liquid, crude oil (Stefano Ponte 2002, p. 1101). Trade has become more diverse. Coffee now ranks third in export value among non-animal agricultural products (at the SITC 4-digit level, see Robert C. Feenstra, Robert E. Lipsey, Haiyan Deng, Alyson C. Ma and Hengyong Mo 2005, revised and updated).

6.1 The Global Integration of Production

Trade is not as simple as David Ricardo's example of exchanging Portuguese wine for English cloth. Today, the trade of final consumer goods accounts only for a fraction of international shipments. Increasingly industries trade *half*-finished products, components, and intermediate services, which enter later production stages elsewhere. English fertilizer goes into Portuguese vineyards, and Portuguese pigments are used to dye English cloth. The supply chain itself has become global.

Value added is the value of an output less the value of its intermediate inputs. Homemade value added is the value of an output less the value of its foreign-sourced intermediate inputs. In a comprehensive data project, Robert C. Johnson and Guillermo Noguera (2012*b*) compute the **homemade** value added of every country's exports. It has fallen significantly over the past three decades. In North America homemade value added dropped from 94 cents for every dollar of goods exported in 1975 to 85 cents today. In East Asia, the homemade value added fell from 88 cents to 79 cents per dollar of exports, and in Europe from 87 cents to 79 cents. Most of the drop occurred recently, so the global integration of production is accelerating.

The homemade value of exports is falling because ever better logistics allow global trade of materials, intermediate goods and services to grow fast. Some economists liken this recent wave of globalization to another industrial revolution (Alan S. Blinder 2006).

Do we really need to make the distinction between intermediate inputs and final consumption goods? Milk is an intermediate input to the cheese industry, but we also drink it as a final consumption good. Architecture services are an intermediate input to commercial construction, but we also contract architects for our residential needs. Why should we discern identical products by user? A key stylized fact about international trade since the Second World War is that trade has grown considerably more rapidly than world output. One explanation is that trade barriers such as tariffs have come down sharply over various rounds of trade agreements. Another explanation is that improvements in transport and communication technologies facilitate global procurement. However, in an influential study Kei Mu Yi (2003) has documented that classic theory with only trade in final products fails to predict the magnitude of trade growth under either explanation. Only when Yi augments the classic trade model and includes intermediate inputs can the model generate the observed trade expansion. In his extended model, the decrease in tariffs and transport costs boosts trade in both intermediate inputs and final goods, and therefore propels overall trade volumes strongly.

There are many descriptions for trade in components, half-finished products, and intermediate services. Some observers refer to intermediate trade as the *international integration of production* because the production process now combines components and services from many locations across the globe. One could just as well call the same phenomenon the international *disintegration of production* because the complete assembly of a final product from scratch is now frequently sliced up into stages that are dispersed around the world.

Offshoring and outsourcing. A common, and precise, term to describe the global integration of production is **offshoring**. Offshoring is the procurement of intermediate inputs from abroad. Offshoring thus characterizes a production stage by its location: outside a country's borders, not within. Intermediate production steps can be located offshore (abroad) or onshore (at home).

Unfortunately, the same phenomenon is sometimes also called *outsourcing*. But in microeconomics and industrial organization the term outsourcing has been reserved for a long time to mean something completely different. The conventional notion of outsourcing relates to the make-or-buy

Table 6.1: Offshoring and Outsourcing

Offshoring Decision	Make-or-Buy (Outsourcing) Decision *Production within firm boundaries*	*Production outside firm boundaries*
Location within home borders	In-house onshore production	Arm's length onshore production
Location outside home borders	In-house offshoring	Arm's length offshoring

decision that a firm makes for the production of its output. If a production stage is not kept in-house (within the firm) but is sent to another firm to perform, then it is said to be outsourced.

Firms have four options when it comes to the make-or-buy decision. Table 6.1 depicts them. First, there is basic **in-house onshore production**, whereby a firm makes all of its parts itself in its home country. Second, there is **arm's length onshore production**, whereby a firm procures components from suppliers in its home country .

The third option is **arm's length offshoring**, whereby a firm acquires materials, components and intermediate services from other companies unrelated to it abroad. In practice, however, much of today's cross-border trade happens within multinational firms (MNFs). Multinational firms own and manage their foreign affiliates and subsidiaries. Around half of U.S. imports may now be trade within multinational firms or groups. Fourth and last, therefore, is **in-house offshoring**, whereby a multinational firm imports some of its intermediate inputs from its own foreign affiliates. In Chapter 13 we will analyze the trade that goes on within multinational firms as opposed to trade with a firm's arm's length suppliers. In this chapter we will simply look at offshoring as an industry-wide phenomenon.

Of course, there still is trade in final products. We should therefore not replace trade theory as we have seen it because it explains final-goods trade. Instead, we need to augment the framework and bring in trade of intermediate products and services produced abroad. This chapter embeds offshoring into the Heckscher-Ohlin model. There are several ways to do it. They all have one feature in common: The production process—the production function in our model—now combines production factors from different locations into the final output. Production factors no longer need to be present on site. However, the essence of the Heckscher-Ohlin model remains in place. The Heckscher-Ohlin explanation for trade rests on the combination of a country characteristic with an industry characteristic. Countries differ in factor endowments, which we describe in terms of abundance. Some countries are relatively more abundantly endowed with high-skilled labor, other countries are relatively more abundant with low-skilled labor. The industry characteristic has to do with factor uses, which we call factor intensities. Some industries, and also some production stages, require high skills relatively more intensively than other industries or other production stages.

The two approaches to offshoring in this chapter differ in their view of the key force for offshoring. In one view, the fundamental driving force for offshoring is the varying requirement of labor skills for different production stages. The main point of the analysis then is to figure out where the different production stages locate given local skill supply. In another view, the fundamental force behind offshoring is the contracting cost for the performed tasks. The main issue then becomes which production factor gets to pocket the contracting cost savings. The two approaches have contrary consequences for earnings inequality.

Think Twice about Convention: *Offshoring is Virtual Migration*

Why bother with production stages and contracting costs? Sure, we need to bring factors from abroad into local production. In other words, we have to allow inputs to be contracted from abroad. Isn't that enough? What if we were to think of offshoring simply as "virtual migration" of foreign labor in the Heckscher-Ohlin model? Imagine work can be "beamed" at no extra cost around the globe, just as easily as information can be sent over electronic networks. This virtual labor is used in final production at the home location. If virtual labor were all there is to offshoring, we would have the answers ready. You have seen them in Chapter 4 when we discussed migration.

Keep the assumptions of the original Heckscher-Ohlin model, except one modification. Concretely, keep the assumptions that industries differ in terms of how intensively they use two production factors; countries differ in terms of how well they are endowed with these factors; the factors can shift costlessly between industries; there is only one production stage and there are no transport or contracting costs. The one modification: Assume that because of virtual migration labor can be contracted at no extra cost across countries.

What happens as offshore labor starts to virtually migrate into home production? Virtual foreign labor increases the economy's labor endowment. The answer therefore must be the same as that for physical migration, which Rybczynski (1955) first worked out: If the endowment of one factor increases, then output of the industry that relatively intensely uses the factor expands, and the output in the other industry contracts under free final-goods trade and incomplete specialization. Product prices, factor prices and factor intensities remain unchanged. Applied to virtual migration, the Rybczynski Theorem tells us that offshoring will not affect factor prices and the use of these factors relative to one another in production. Offshoring will merely change the location of production: The industry that intensely uses the virtually migrating factor will shrink in the migrants' country of origin and expand in the migrants' destination country. Is that realistic?

Probably not. In the model, wages equalize around the world, so the "virtual migrants" earn the same wage everywhere and the location of production activities is not determined. Where production stages end up is a matter of chance. In practice, the location of manufacturing activities appears to be more systematic. Take the coffee supply chain. The blending and roasting stages are typically located in consumer countries where wages and labor productivity tend to be higher than in the growers' countries. Theory should do better in matching that pattern, which is common in food and beverage industries. One idea is to model production stages explicitly and to allow blending and roasting to be more intensive in skilled labor than coffee growing. Consumer countries tend to be more abundant in skilled labor. Another idea is to discern between different tasks and allow contracting the tasks to be more or less costly at a distance. Blending, for instance, involves much tacit knowledge about both coffee qualities and consumer tastes, and is arguably difficult to contract offshore. This chapter takes on both ideas in turn.

6.2 Offshoring Production Stages

A natural way to broaden classic trade theory is to bring in individual production stages. Feenstra and Hanson (1996) carry out such a theoretical analysis. They let **production stages** differ in the intensity of labor skill requirements and show that offshoring then has strong implications for income inequality within each economy. The basic mechanism is perhaps best conveyed by a fact, and by a joke that MIT and Harvard students are said to tell about each other.

First the fact: When U.S. residents sold used cars on a large scale to Mexico after the formation of the North American Free Trade Area (NAFTA) in 1994, the *average* fuel efficiency of automobiles in both countries improved. How can the average car on the road become less polluting everywhere just by pushing used cars from one place to another? The explanation is that the used cars Mexico imported from the United States were more fuel efficient and less polluting than the typical Mexican car. Even if the used car imports displaced not a single Mexican automobile, the average fuel efficiency in Mexico must have gone up because the Mexican average started to include more efficient cars. Meanwhile, the cars left on U.S. roads had become more fuel efficient on average, too, because the least efficient cars had been shipped to Mexico. The average fuel efficiency of the remaining cars on U.S. roads went up as well.

Now to the joke: MIT students claim that when their underperforming classmates drop out and move over to Harvard University, then the grade point averages at both schools rise. For this claim to be true, of course, the MIT students must presume that the underperforming students, on average, outperform the Harvard students. Harvard students seem to tell the same joke about their classmates who dropout and transfer to MIT. The explanation behind the used-car puzzle and the joke is essentially the same as the explanation for the income effects from offshoring: When offshoring occurs, then the average production stage in both the "inshoring" and the "offshoring" economy becomes more skill intensive. As a result, the gap between wages paid to high-skilled and to low-skilled people widens within every economy.

Much of the concern with offshoring and inequality relates to the relative incomes of high-skilled versus low-skilled workers. For the remainder of the chapter, let us therefore consider high-skilled labor H and low-skilled labor L as our two factors of production. There are many **production stages** s. Each production stage requires a different combination of high-skilled labor and low-skilled labor. A high $H(s)/L(s)$ ratio means that the stage s is high-skill intensive. Other stages require a low

Fundamentals.

- *Key force*: Factor intensities of production stages and endowments (interact production-stage and country characteristics)
- Factors of production: 2 (high-skilled labor H and low-skilled labor L)
- Factor mobility: both factors mobile between industries, immobile across borders (no virtual migration)
- Industries (goods): 2. Agriculture Q_A and Manufacturing Q_M (both made with H and L)
- Production stages: **Multiple** (continuum)
- Countries: 2 (Onshore Home and Offshore Foreign*)
- Perfect competition, transport costs: 0 (Law of One Price)
- Constant returns to scale
- Balanced trade (exports pay for imports)
- Contracts perfectly enforceable

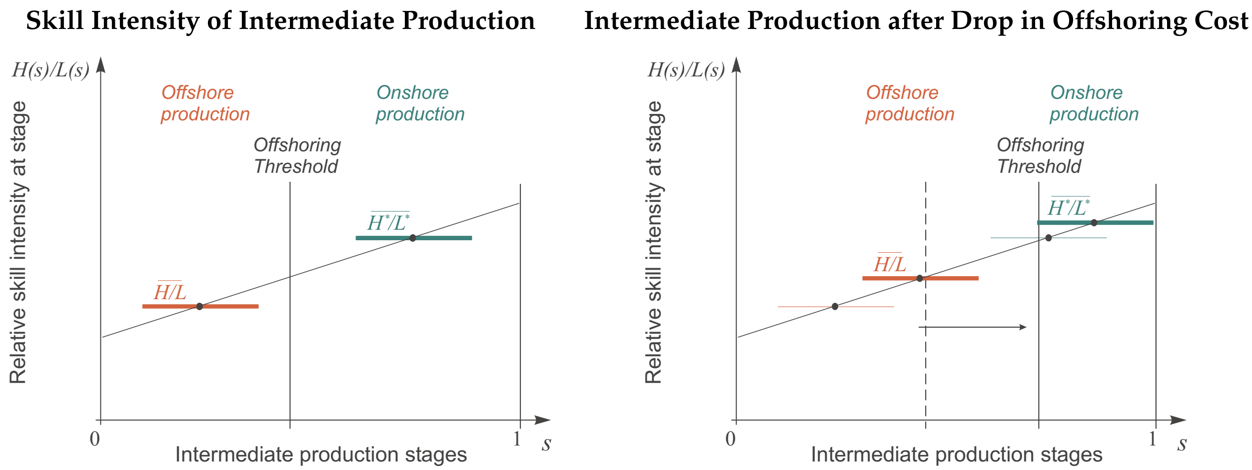


Figure 6.1: Stages of Intermediate Production and Offshoring

intensity of high-skilled labor relative to low-skilled labor, a low $H(s)/L(s)$ ratio.

To analyze offshoring for multiple production stages, we can apply a simple trick. It is a similar trick as we used for multiple industries when we discussed the extended Ricardian model in Chapter 3. Now we rank the production stages by a particular characteristic. The characteristic we use is skill intensity. In Figure 6.1 the vertical axis measures the skill intensity of a production stage.

The left panel of Figure 6.1 shows the stages of production on the horizontal axis, starting on the left with the first stage, which is named $s = 0$, and moving to the right to the last stage, which is named $s = 1$. The names of the stages are just labels. To make matters simple, production stages with low skill intensities are given low-level labels. For example, $H(0)/L(0)$ is the least skill intensive stage. By contrast, stages with high skill intensities are given high-level labels. For example, $H(1)/L(1)$ is the most skill intensive stage. Under our labelling convention, we can pick any two stages (the one at $s = .312$, say, and the one at .671) and we know that the one with the high-level label is more skill intensive than the one with the low-level label. Inputs from every single production stage are necessary to assemble the final products.

In a conventional Heckscher-Ohlin framework, the wage ratio w_H/w_L is typically the same everywhere, even if productivity differences between countries result in different wages around the world. We have seen examples in Chapters 4 and 5. No longer here, in the presence of multiple production stages. Suppose the home economy is more abundantly endowed with high-skilled labor than the rest of the world. If this is the case, then it will be relatively less expensive to hire high-skilled labor in the home economy than it will be in the foreign economy, and

$$w_H/w_L < w_H^*/w_L^*.$$

As a consequence, when a final-goods assembler (such as a blender and roaster of coffee, for example) looks at the cost of intermediate inputs, the assembler finds the cost to increase relatively fast from one stage to the next in the offshore economy. As assembly moves from left (low-skill intensive) to right (high-skill intensive) in Figure 6.1, the cost of high-skilled labor goes up sharply in the foreign economy, where w_H^*/w_L^* is high. In contrast, when the same assembler looks at intermediate-input suppliers that produce in the home economy, the production cost starts at a higher level but increases more slowly when moving from low-skill to high-skill intensive stages because w_H/w_L is relatively low.

This implies that there is a unique threshold of skill intensity. Below the threshold, it is less costly for an assembler to locate intermediate production offshore. Above the threshold, it is less costly to locate intermediate production onshore. (Mathematical Appendix 6.I proves the threshold is unique.)

What can we say about relative labor demand in each economy? The production stages located in each country, abroad and at home, are diverse. But we can figure out what the average factor intensity by country is, which is a relevant measure of the demand for the factor in a country as a whole.

In the left panel of Figure 6.1, the average skill intensities are depicted with thick bars. The average intensities are situated at the midpoints between each vertical axis and the threshold. The average high-skill intensity H^*/L^* (in red) abroad is lower than the average high-skill intensity H/L at home (in green). Put another way, there is relatively greater demand for high skills in the home economy. The simple reason is that we started with the assumption that the home economy is more abundantly endowed with high skills. It has a relatively low w_H/w_L ratio, so the demand for high-skill intensive labor is strong.

Now suppose offshoring costs drop. As a consequence, the relative cost of procuring intermediate inputs from offshore falls and, at any given wage ratios w_H/w_L and w_H^*/w_L^*, locating production stages offshore becomes more attractive. What happens to the global supply chain and the location of production stages in this case? The offshoring threshold must shift. The right panel of Figure 6.1 depicts this scenario. As it becomes less expensive to offshore production stages, firms locate more of them abroad. In other words, the offshoring threshold shifts right, and all of the production stages between the old and the new threshold are those that leave the home economy for an offshore location.

Take the example of the coffee supply chain. A few globally active traders ship the raw beans from farmers around the world to the final roasters in consumer countries. Neumann (based in Germany), Volcafé, Decotrade and Taloca (all based in Switzerland), Cargill (based in Minnesota/USA), Olam (based in Singapore) and Noble Coffee (based in Hong Kong) handle the bulk of worldwide coffee trade today. They operate global networks and often enter agreements with farmers and local middlemen in the grower countries. An important part of a trader's responsibility is to guarantee quality and taste, which requires careful screening and sorting of diverse coffee batches. Quality beans need to be separated from the main crop by size, shape and taste; this takes sophisticated measuring equipment and skill. Screening is arguably a relatively high-skill intensive activity compared to growing and harvesting, but a relatively low-skilled activity compared to roasting, blending and marketing in the consumer countries. For decades, traders used to pool much of the screening and handling outside the grower countries because, under the International Coffee Agreement (ICA), varying export quotas and other trade restrictions made it difficult and risky to keep coffee stored in grower countries. With the collapse of the ICA in 1989, however, the traders have shifted much of the screening, sorting and handling to local contract partners in grower countries. In other words, offshoring costs came down sharply around 1989. If screening was a production stage close to the offshoring threshold around 1989, then our theory predicts that screening activities shift to grower countries.

What can we say about relative skill demands in each economy? In the model, the average high-skill intensities are again situated at the midpoints between each vertical axis and the threshold, but these midpoints now move to the right in both countries. Why? The explanation is the same one we illustrated with the used-car example and the MIT-Harvard joke. As the home economy gets rid of its low-skill intensive production stages, the average skill requirement of the workers employed there increases. However, the least skill-intensive stages for the home country still require higher skill levels, on average, than the average skill level needed offshore. In fact, the least skill intensive production stage at home is still more skill intensive than even the most skill intensive stage offshore.

As the foreign offshore economy takes on more high-skill intensive production stages, the average skill requirement of its production H^*/L^* (which is shown in red) also increases. In the foreign economy, workers leave employment at low-skill intensive production stages and move on to work in high-skill intensive stages. In the home economy, in contrast, workers are laid off from the relatively low-skill intensive production stages that go out of business and move to the remaining high-skill intensive stages.[2] The average skill intensity in the offshore economy is still lower than the average skill intensity H/L at home (shown in green), but both intensities have gone up.

Think back to the example of the coffee supply chain. Screening coffee by quality and taste is a relatively high-skill intensive activity compared to growing and harvesting. Bringing the screening activity to the growers' country therefore raises the average skill intensity of economic activities in the grower country. In contrast, screening is low-skill intensive compared to the more advanced economic activities in a consumer country. Losing screening to the coffee growing country therefore also raises the average skill intensity of the consumer country's economic activity. Adding an activity at the high-skill end raises average skill intensity, just as losing an activity at the low-skill end also raises average skill intensity. If food screening and handling is an important activity for the grower country and the trader country, then relative skill demand goes up in both countries.

In the model, what will happen to relative wages of the workers in the two countries as a consequence? If high-skilled workers are in higher demand in an economy, their relative wage w_H/w_L will rise. Average skill intensity of production increases in both countries with offshoring, so we can expect the demand for high-skilled workers to increase everywhere in the world when offshoring costs drop. As a result, wage inequality increases everywhere in the world as offshoring progresses. In fact, during the final two decades of the past century, many countries in the world experienced an increase in inequality.[3] Our analysis suggests that offshoring may explain the growing inequality of people's earnings around the world when there are multiple production stages.

Let's relate our new insights back to the Heckscher-Ohlin model when only final goods are being traded (as in Chapters 4 and 5). The Stolper-Samuelson Theorem tells us that an economy's relatively abundant factor strictly gains from free trade in final goods whereas the relatively scarce factor strictly loses in real terms when the economy opens up. Suppose the home economy is relatively abundant in high-skilled labor. Then opening to free trade will raise the real income of the high-skilled domestic workers and widen the income gap between them and low-skilled domestic workers. In contrast, high-skilled labor the relatively scarce factor offshore. Free final-goods trade will therefore lower the real income of the high-skilled workers abroad and narrow the income gap between them and low-skilled workers there. The classic Heckscher-Ohlin model with two factors and two goods therefore predicts that free trade worsen income inequality in developed economies but shrinks the income gap in developing countries. In contrast, trade in intermediate inputs across multiple production stages in

[2]If the resulting change in labor supply does not match labor demands in manufacturing then workers shift in or out of other sectors in the background such as agriculture or services.

[3]You can look back at Figure 1.3 in the introduction and verify that within-country inequality went up on average around the world since the Second World War. Anthony B. Atkinson, Thomas Piketty and Emmanuel Saez (2011) document that, over the last thirty years, incomes at the top have pulled away markedly from other income groups in English speaking countries and in India and China, but not in continental European countries or Japan. Pinelopi K. Goldberg and Nina Pavcnik (2007) review a large body of evidence on growing wage inequality in developing countries.

this Chapter completely overturns the prediction for low-skilled workers in developing countries. In other words, offshoring now predicts rising income inequality everywhere, including in developing countries. Over the past decades, income inequality went up indeed in many developing countries.

6.3 Trade in Tasks

So far, we have treated all workers with a given skill level as if they performed identical tasks on their jobs. That is unrealistic. Workers with the same training, such as economics majors say, perform different tasks on their jobs—ranging from client or supplier communication, to analysis or quality control, to planning or supervision. Do tasks matter for trade? Workers' efforts enter a production function, a classic economist might argue, their effort ultimately generates a tradable output, and that is that.

Well, here are two examples. First think of doormen. Even though the tasks of a doorman may not require much schooling or extensive training, his job cannot be offshored. Now think of radiologists, who undergo a great deal of schooling and training. Radiology images can easily be sent around the globe and displayed remotely. That in fact is what increasingly happens; it is called teleradiology. Clinics and hospitals are taking the images and transmitting them to radiologists in countries with lower labor costs. In short, whether or not a job is easily offshored need not be related to the skills and education associated with it. In fact, examples like these have raised the concern that commonly well-paid jobs, and relatively well educated workers, may come under particular pressure from offshoring. Tasks matter.

Researchers have identified a number of job features that may make it especially inexpensive to offshore a task. If the information to execute a task can be written down ("codified") in a set of instructions that are easy to follow, then the task should be relatively easy to offshore (Edward E. Leamer and Michael Storper 2001). Similarly, if a task involves many "routine" actions, then it should also be easy to offshore (Frank Levy and Richard J. Murnane 2004). Grossman and Rossi-Hansberg worked out some striking implications of this type of trade at varying contracting costs.

Fundamentals.

- *Key force*: Varying offshoring costs by task (industry and country characteristics for goods)
- Factors of production: 2 (high-skilled labor H and low-skilled labor L)
- Factor mobility: both factors mobile between industries and tasks, H factor contractible across borders (costly virtual migration)
- Industries (goods): 2. Agriculture Q_A and Manufacturing Q_M (both made with H and L under task assignment)
- Production stages: 1 single final stage
- Countries: 2 (Onshore Home and Offshore Foreign*)
- Perfect competition, task contracting costs: $\tau(j)$ per task j (Law of One Price for goods)
- Constant returns to scale
- Balanced trade (exports pay for imports)
- Contracts perfectly enforceable

To make task trade happen, let's go back to the classic Heckscher-Ohlin model as you saw it in Chapters 4 and 5. We reuse that classic model to keep trade in final products active for realism. There are two factors of production in the benchmark model, and we can think of them as low-skilled and high-skilled labor like above. We make two important modifications. First, we allow tasks to be contracted from offshore. There is an extra contracting cost if the task is performed offshore instead of at home. We then need a second change to the conventional Heckscher-Ohlin model. There must be a **wage gap** between the home and foreign country. If wages were equal everywhere, then no producer would offshore any task because no producer could make up the extra cost of contracting abroad. We call the wage gap ω. It applies to wages of both the low skilled and the high skilled workers:

$$\omega = w_L/w_L^* = w_H/w_H^* > 1.$$

The wage gap ω opens an opportunity for offshoring: Foreign labor is less expensive in terms of wages than labor at home. But foreign labor can be put to more productive use in the home economy. That productivity advantage is the reason for the relatively higher wage at home. Even under the extra contracting cost it can therefore become worthwhile to offshore some tasks.[4]

The crucial characteristic of tasks for trade is their contracting cost when they are offshored. It is less costly to offshore tasks if they are easily written down in instructions, if they are routine, and require little personal proximity for interactions. For simplicity, we will make high-skilled labor the only factor that can be contracted offshore. Some radiology jobs may move offshore. The doormen jobs do not. (We could make tasks by the L factor offshorable as well and get similar insights.)

There are many tasks. Each task gets its own label j. When an employer contracts tasks with workers at home who are highly skilled, then the employer simply pays them the going domestic wage w_H. For a task contracted from H^* labor abroad, the foreign factor price is w_H^* and needs to be paid. In addition, there is a contracting cost multiplier of $\tau(j) > 1$ for every task j so that the overall cost of traded tasks becomes

$$\tau(j) \cdot w_H^*.$$

We can rank tasks by their costs, similar to the trick before. At one end of the range, we can place the tasks that cost relatively little to offshore so that $\tau(j)$ is low. The lowest-ranked task incurs minimal offshoring costs of τ_0, say, so $t(0) = \tau_0$ and the task with label $j = 0$ is the cheapest one to offshore. Then come tasks that are increasingly costly to offshore. High-level labels are assigned to tasks with high offshoring costs: $t(1)$ is the contracting cost of the most expensive task to offshore. The left panel of Figure 6.2 shows the tasks on the horizontal axis, starting with the least-costly task named 0 and moving to the right through the range of tasks up to the last and most costly task named 1. The result of this convention is an increasing schedule of offshoring costs per task. The schedule can take many shapes, with flat and increasing parts wobbling around. We only know that the offshoring cost schedule can never bend back downwards under the rank ordering. To make life simple, the Figure depicts a linear schedule of offshoring costs with

$$\tau(j) = \tau_0 + \tau \cdot j.$$

(Mathematical Appendix 6.II presents an alternative offshoring cost schedule.)

[4]You may wonder where the wage gap comes from. After all, the conventional Heckscher-Ohlin model (as in Chapter 4) predicts that factor prices equalize under free trade in final goods: no wage gap ($\omega = 1$). Chapter 5 shows the way out. Suppose the home country is able to boost each industry's output by a multiplier A. This booster is called **TFP** for **total factor productivity**. The foreign country, in contrast, only has a small TFP booster $A^* < A$. It turns out that, under this generalization, all the main features of the benchmark Heckscher-Ohlin model continue to be correct (the Heckscher-Ohlin Theorem, the Stolper-Samuelson Theorem and the Rybczynski Theorem still hold unaltered; see Chapter 5). Just one theorem becomes more general: there is now *conditional factor price equalization*. For the high-skilled workers, wages are "conditionally equal" after adjusting for the productivity gap, so that $w_H = (A/A^*)w_H^*$. Similarly for low-skilled workers, $w_L = (A/A^*)w_L^*$. The cross-country wage gap becomes $\omega = w_L/w_L^* = w_H/w_H^* = A/A^* > 1$.

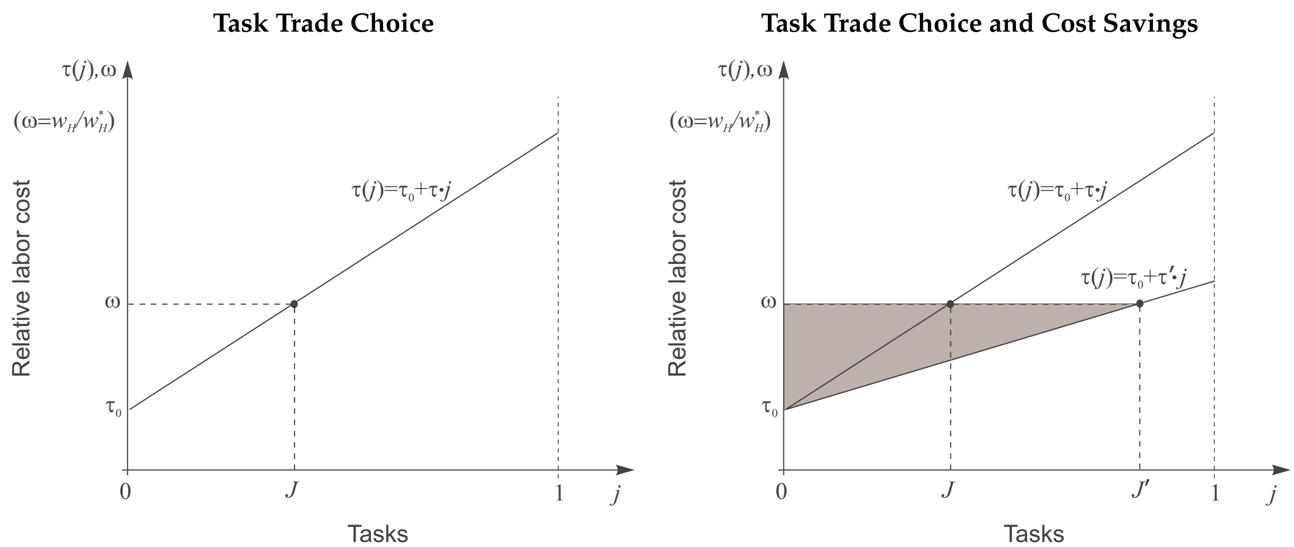


Figure 6.2: Trade in Tasks

A simple contracting rule is as follows: Contract a task from offshore if the labor cost for the task from abroad $\tau(j)\, w_H^*$ is at least as low as the onshore wage rate w_H:

$$\tau(j)\, w_H^* \leq w_H.$$

Otherwise hire domestic workers to perform the task for you. If the home wage exceeds the foreign wage times the contracting cost multiplier $\tau(j)$, then the task is cheaper to perform offshore. According to the rule, an industry will optimally stop contracting offshore work at a cutoff task J, where $\tau(J) \cdot w_H^* = w_H$. Using the wage gap $\omega = w_H/w_H^*$ to rewrite the optimal foreign contracting rule, the last task to offshore J is the one whose cost $\tau(J)$ satisfies

$$\omega = \tau(J).$$

The optimal stopping point for offshoring is depicted in the left panel of Figure 6.2. Below the cutoff task J it is less costly to contract tasks abroad than at home. Above J it is less costly to employ domestic labor. The left panel of Figure 6.2 depicts this initial equilibrium. In the initial equilibrium, some offshoring already takes place. Offshore labor is performing the range of tasks up to J. For linear offshoring costs, it is easy to find J explicitly by solving the equations $\omega = \tau(J)$ and $\tau(J) = \tau_0 + \tau \cdot J$. The cutoff task is

$$J = \frac{\omega - \tau_0}{\tau}.$$

This solution has an intuitive interpretation. The wider the cross-country wage gap ω is, the more offshoring there is (the further to the right the cutoff task J is). The lower the minimal offshoring cost τ_0 is and the lower the marginal offshoring cost component τ is, the more offshoring there is (the further to the right the cutoff task J is).

Suppose marginal offshoring costs drop for all tasks, that is τ falls to $\tau' < \tau$. How does J change? As shown in the right panel of Figure 6.2, the optimal stopping point for offshoring, J, shifts to the right to the level J'. The range of tasks between the former cutoff task J and the new threshold J' are now being performed by foreign, high-skilled workers.

How about evidence from the coffee supply chain? Coffee blending and roasting is in the hands of just a few globally active food processing companies today: The top five coffee processors Nestlé (Switzerland), Kraft (Illinois/USA), Sara Lee (Netherlands), Folgers (California/USA) and Tchibo (Germany) now handle more than half of the worldwide coffee roasting and marketing. The roasters themselves used to operate large warehouses in the consumer countries, compile coffee supplies from various origins, and to put together fairly homogeneous coffee products. Warehousing, however, is a relatively routine task and it is easy to write down and communicate instructions for storage and delivery. In other words, contracting costs for warehousing are relatively low. With new communication methods and shorter international shipping times the offshoring cost schedule has fallen. Roasters now leave most of the warehousing tasks to global traders. In other words, the decline in offshoring costs has prompted roasters to specialize more narrowly in their core tasks of blending and marketing. Relatively routine tasks have shifted to the traders, who in turn operate more and more warehouses in grower countries. Traders now integrate the supply of beans across origins and storage locations worldwide, switching seamlessly between the types of coffee beans Nestlé, Kraft, Sara Lee, Folger, and Tchibo require for their diverse customers around the world. Coffee traders now regularly store raw beans for up to two years until the beans' origins and tastes fit nicely into a roaster's need for a specialty blend.

What are the benefits of offshoring? Every foreign high-skilled worker receives a wage w_H^*. But the domestic industry does not pay a constant cost for each offshored task. To the contrary, for the very first offshored task, the industry pays only $\tau_0 w_H^* < w_H$. For the last offshored task it pays much more: $\tau(J')w_H^* = w_H$. So the industry offshores and perfectly price discriminates by paying less than w_H for all the tasks below the cutoff. This generates cost savings for the domestic industry. Microeconomists call this extra benefit from cost savings a *quasi rent*.

The cost savings is depicted as the grey-shaded area in the right panel of Figure 6.2. The cost savings from offshoring are tiny in the beginning when tasks are first being offshored. This is because when an economy first starts offshoring from zero (an initial J level of 0), the cost savings are negligible (there is no grey triangle with a positive area yet). Initially the minor cost-savings will be hard to detect. For linear offshoring costs, it is easy to compute the grey area explicitly by using the formula for a right-angled triangle: $J' \cdot (\omega - \tau_0)/2 = (\omega - \tau_0)^2/(2\tau)$. By the formula, the initial task offshored, $j = 0$, provides large cost savings, which is $\omega - \tau_0$. The final task offshored, J, provides zero cost savings. The average cost savings per task is therefore $(\omega - \tau_0)/2$. Because there are J' offshored tasks, the total cost savings amount to $J' \cdot (\omega - \tau_0)/2$.

Who gets to pocket the cost savings? Not the producers. There is perfect competition before and after offshoring, so there are no profits for any industry. Under free final-goods trade and incomplete specialization, final goods prices are fixed. So w_L and w_L^* remain unchanged with $w_L = (A/A^*)w_L^*$. Similarly, w_H^* remains unchanged. Foreign H^* workers are contracted at their old wage w_H^* given their unchanged labor productivity $1/a_{Hi}^*$ in both industries i abroad (i can be A for agriculture or M for manufacturing).

The only factor of production that can pocket the cost savings are high-skilled workers at home. Mathematical Appendix 6.II shows how this result is derived. We can come to the same conclusion by thinking about the problem intuitively: Home H workers are the only factor of production susceptible to offshoring. L workers cannot be offshored, and the foreign wage is below the home wage, $w_H^* < w_H$. Thus, there is no incentive for the home country to offshore high-skilled labor to the foreign country. The only type of offshoring that will happen in equilibrium is this one: some H^*

workers are hired at the foreign wage $w_H^* < w_H$ to remotely work for the home economy.

What do the high-skilled workers at home do as offshoring progresses? There is full employment, so all of them will have a job before and after offshoring. But the range of tasks they do changes. Before, they had to perform quite a broad mix of tasks between J and 1 (or 0 and 1 if there was no offshoring at all). After offshoring, they carry out a narrow range of tasks from J' to 1. The change in the tasks they do opens up the opportunity for cost savings. The cost savings arise because each foreign task is contracted at its individual cost. All of the offshored tasks, except the very last one, cost less than if they were done domestically: $\tau(j)w_H^* < w_H$ for all $j < J'$. This cost savings is paid to the home H workers and to no one else.

Did H workers at home become more productive with offshoring? No. Offshoring does not alter their performance or productivity. In fact, the labor productivity of an H worker at home is still $1/a_{Hi}$ in every industry i and therefore unchanged.

To see more clearly how the perfect price discrimination of offshoring plays out, let's explore the opposite scenario. Instead of having varying costs, let's step outside the model we worked out and suppose there is a single cost of $\bar{\tau}$ for every offshored task, so $\bar{\tau}$ does not change across the range of tasks: $\tau(j) = \bar{\tau}$. Then the cost of all offshored tasks is $\bar{\tau}w_H^* = w_H$. In equilibrium, it must be the case that the constant offshoring cost is just as high as the wage gap: $\bar{\tau} = \omega$. (Otherwise there would either be never any offshoring at all, or all H^* would be hired as offshore labor, and we would end up with complete rather than incomplete specialization.) When $\bar{\tau} = \omega$, then it doesn't matter whether the factor of production is contracted from offshore or not. Nobody gains or loses from offshoring. Sounds familiar? For constant offshoring costs, we are back in the case of virtual migration from the think-twice box on page 172 above (virtually the same as the case of migration in Section 4.4 of Chapter 4). The high-skilled workers at home could still be assigned to a narrower range of tasks, but their wage w_H would be the same before and after offshoring. In the task-trade modelnow the H workers at home are more lucky than that, however. Offshoring costs are paid task by task in a perfectly discriminatory way, and $\tau(j) < \tau(J')$ for all offshored tasks up to the last one offshored. As a result, there is a cost savings from offshoring, and this cost savings increases as the range of offshored tasks widens. The domestic H workers pocket the savings in the form of a higher wage.

What happens in the market for radiologists? All domestic radiologists remain employed, but they get assigned to higher-end tasks that are more costly to offshore—such as final diagnostics, the treatment of non-routine health conditions, or training rookie radiologists, for example. Meanwhile, their foreign colleagues do the basic processing of images, the updating of medical files, and so on. If the home medical industry is able to perfectly price-discriminate when it comes to each of these offshored activities, this generates cost savings. Because the domestic radiologists focus on high-end tasks, they get to pocket the savings in the form of higher wages. Even though radiologists may have been more afraid of wage losses to globalization than doormen, radiologists may in fact gain from the cost savings. In contrast, if the home medical industry did not get to perfectly price discriminate task by task, we would be back to the case of virtual migration and the domestic radiologists would neither gain nor lose from offshoring.

Overall, we now have three theoretical predictions as to how offshoring will affect the labor market. First, if there were only a single production stage and virtual migration were costless, then no factor price would change. This is the case of virtual migration from the think-twice box on page 172 above. Second, if there are multiple production stages but trading intermediate inputs is costless, then we are in the world of the Feenstra and Hanson model and can expect inequality to increase everywhere in the world at both onshore and offshore locations. Workers in the home economy with the training important for high-skill intensive production stages are *least* likely to see their jobs offshored, and gain. Third, if there is only a single production stage and industries can perfectly price discriminate in terms of the contracting costs they pay for the tasks they offshore, then we are in the world of the Grossman and Rossi-Hansberg model for trade in tasks. The workers whose occupations are *most* susceptible to offshoring gain from the cost savings that their industries generate. Taken together, it is unclear which workers should fear offshoring. The empirical evidence on offshoring that researchers have uncovered to date does not offer a clear conclusion either.

Think Twice about Convention: *Comparative Advantage and All That*

Have you noticed that not once in this chapter has the principle of comparative advantage come up? Are we finally rid of comparative advantage and all that? Economic research into the trade of intermediate inputs and offshoring has left us with a range of predictions, and apparently little common ground. So, if we want to find out what really happens when intermediate tasks are offshored, we may need to round up the two usual suspects: opportunity cost and comparative advantage.

With virtual migration, no location has a comparative advantage because remotely contracted virtual migrants come at exactly the same cost as domestic workers. There are no trade gains from virtual migration, but also no losses, because we got ourselves into the unlikely case that the opportunity costs of inputs are perfectly identical everywhere around the world.

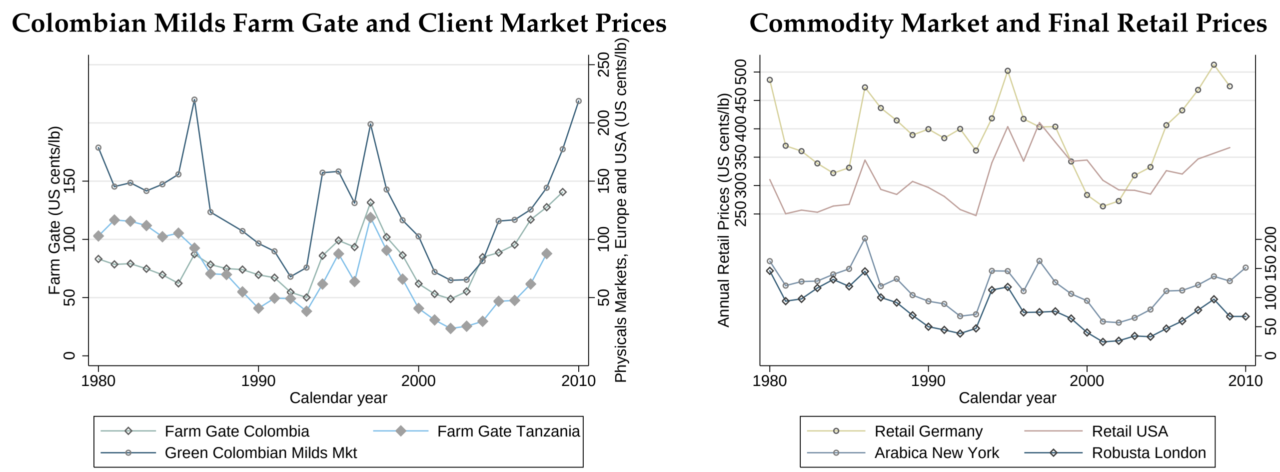
Then there is offshoring of production stages that differ in skill intensity. Opportunity cost and comparative advantage are back now, not for final good assembly, but for input trade. Production stages up to a threshold are located offshore. We could also say, up to the threshold, the opportunity cost of intermediate-input production is lower in the offshore economy. From the threshold onwards, the onshore economy has a lower opportunity cost in intermediate-input production. The explanation why high-skill intensive production stages are kept onshore is therefore one of comparative advantage.

Finally there is trade in tasks under varying offshoring costs. For the home economy, tasks up to the cutoff task are provided from offshore. We could also say, up to the cutoff task, the opportunity cost of H-employment is lower in the offshore economy. Or say, up to the cutoff task, the H^* workforce in the offshore economy has a comparative advantage in the respective tasks. From the cutoff onwards, H labor in the onshore economy has a comparative advantage. In short, the two usual suspects—opportunity cost and comparative advantage—still lurk behind the pattern of specialization, or its absence.

6.4 Global Supply Chains

Sequential supply chains

The coffee supply chain, from growing to processing to final packaging, offers insight into what one could call the **sequential supply chain**. Some economists also refer to this type of supply chain as a "snake"—envisaging the main material as it slithers from raw form to final stage. One essential ingredient, the coffee bean, undergoes a series of transformations until it is made into the final product. Prices at different stages of a sequential supply chain show how value added builds up.



Source: *International Coffee Organization* (ICO), 2011.
Note: Farm gate and retail prices are ICO annual averages. The market price of green Colombian Mild Arabicas is the annual ICO average on the physicals markets for raw coffee in France, Germany and the United States. New York and London prices are annual average NYMEX and Liffe futures prices.

Figure 6.3: Prices of Mild Arabicas and Robustas by Supply Chain Segment, 1980-2010

Two types of coffee beans end up in our cups today: Arabica and Robusta. The Arabica bean is used predominantly in specialty coffees and is typically considered the more flavorful of the two. Arabica coffee commands higher prices. Some espressos are exclusively made of Arabica beans. Most retail bags of ground coffee, however, blend Arabica and Robusta beans. A bag's proportion of Arabica and Robusta beans typically depends on their relative price. For example, if the price of Arabica coffee is relatively high, less of it will be used in the bag.

Arabica beans are mostly traded on the New York Mercantile Exchange (NYMEX), Robusta beans mostly on the London International Financial Futures and Options Exchange (Liffe). The top-end Arabica beans are the so-called Colombian Milds, which grow mainly in Colombia, Kenya and Tanzania. Figure 6.3 tracks coffee prices by supply chain segment. The left panel shows the prices that farmers get "at their farm gates" for Colombian Mild beans in Colombia and Tanzania as well as the average market price for Colombian Mild "green beans" when they arrive in raw form in Europe and the United States. Because Colombian-grown Arabica beans are more highly valued, the farm gate price in Colombia exceeds that in Tanzania by up to 50 cents per pound. A comparison between the Colombian farm-gate price and the market price of the green beans in consumer countries shows that there is not much value added in screening, warehousing, and transporting the coffee beans. As we have explained, the largest increase in value added occurs in industrialized countries where the coffee beans are roasted, ground, and packaged. The right panel compares the retail prices of the roasted coffees to the green-bean prices for Arabica and Robusta at the commodity exchanges in New York and London. In 2009, the average retail price of coffee in Germany was $4.75 per pound for Arabica-Robusta blends. That was about four times more than the price Arabica beans were selling for on the New York and London exchanges, and about 7 times more than the price Robusta beans were selling for.

The success of food-processing companies has turned some of their countries into leading re-exporters of packaged coffee. As Table 6.2 shows, Belgium and Germany rank fourth and fifth in

Table 6.2: Coffee Exports and Re-Exports

Rank	Country	1980	1990	2000	2008
1.	Brazil	15.626	16.936	18.016	29.499
2.	Vietnam	0	1.145	11.618	16.101
3.	Colombia	11.103	13.944	9.177	11.085
4.	Germany	1.234	3.292	4.825	10.406
5.	Belgium	.406	.891	2.357	6.142
6.	Indonesia	3.608	6.903	5.358	5.741
	. . .				
13.	USA	1.642	.825	2.055	2.861
14.	Mexico	2.185	3.683	5.304	2.448

Source: *International Coffee Organization* 2011, millions of 60-kg bags in 2008.

terms of the amount of coffee they export—right after the leading exporter countries Brazil (first), Vietnam (second) and Colombia (third). Protectionist policies in consumer countries continue to distort global coffee trade. European Union countries, North American countries, and Japan impose tariffs and subsidies to protect local industries. Especially European roasters benefit from trade barriers. The European Union assess no tariff on the (raw) green beans, but imposes a 9 percent tariff on roasted beans. It is therefore difficult for economies that now grow, sort and warehouse the beans to also attract the parts of the supply chain that generate most value added: roasting, grinding, and branding coffee.

Change of Perspective: *The Coffee Paradox*

Benoit Daviron and Stefano Ponte (2005) argue that a *Coffee Paradox* characterizes the global supply chain for coffee. A coffee boom in industrialized countries goes hand in hand with a coffee crisis in producing countries. Daviron and Ponte offer unconventional explanations for this divergence. They partly agree with a wide-held view that the 1989 breakdown of the ICA—an agreement among coffee-growing and consuming countries that allowed the growers to impose quotas on the amount of coffee exported —accelerated coffee production and thus depressed coffee prices. Daviron and Ponte also agree that the widening price gap between green beans and final coffee products results from an oligopoly market where a few dominant roasters capture large profits. The authors argue, however, that the oligopoly has arisen for a deeper reason: Marketing by companies such as Folgers, Sara Lee, and their competitors affects people's consumption habits and leads to a certain disassociation from the actual product. In other words, the quality of the original beans, where and how they are grown, doesn't affect consumers much. Instead brand names drive consumer behavior.

How can coffee-bean growing countries break away from commodity trade and into the market for brands where most of the value added to a product is earned? Daviron and Ponte say growers need to market the quality attributes of the coffee beans they produce and label the beans by their geographic origin. In other words, Daviron and Ponte want coffee producers to become more like wine growers and whiskey distillers—but not for the occasional drink, rather for up to 1.5 billion cups of coffee a day.

Dispersed supply rings

Coffee processing is arguably not a representative example for the manufacturing sector as a whole. When it comes to high-tech products such as iPads or airplanes, for instance, a better image than that of a supply chain may be one of **dispersed supply rings**. Think of the Boeing 737 family of airplanes. The 737 model has been one of the workhorse products in the airplane manufacturing industry for almost half a century. After the first flight of a 737 in 1967, it took more than two decades for a serious competitor to emerge: the A320 by Airbus, which was first flown in 1988. Generations of 737 models have carried about 12 billion passengers, and a 737 still takes off somewhere in the world every five seconds (Chris Brady 2012).

After being around for so long, much is known about the 737 component suppliers. A suitable description of the supply arrangement may be one in which the final airplane emerges from the center of a ring (or tier) of inputs, which in turn emerge from preceding rings (tiers) of inputs. There is no single essential ingredient. Each airplane production stage is at a ring's center and combines inputs from the surrounding ring. The surrounding ring itself holds the centers of preceding production rings; those rings in turn hold centers of earlier production rings. Some economists prefer to call similar supply arrangements "spiders"; they really seem to mean spider webs and envisage a combination of rings with multiple connections between outer and inner rings. The first order for a Boeing 737 airplane came from Lufthansa in 1965. That plane and the next 270 were built at Boeing's plant in Seattle. Today, Boeing workers in Renton, Washington, south of Seattle, assemble the final 737 airplanes from around 367,000 parts. But most of the airplanes' parts are built elsewhere. Since 1983, a factory in Kansas has made the fuselages, including the noses and tail cones for the plane, which are then hauled across the country by train. Most of the sub-assembly work today happens at globally active suppliers that specialize in their respective manufacturing industries.

The latest 737 family member—the 737-900ER, where ER stands for extended range or, some suspect, for extra row—gets its vertical fin from Xi'an Aircraft in China, its horizontal stabilizer from Korea Aerospace, its rudder from Bombardier in Ireland, its winglets from Kawasaki in Japan, parts of its landing gear from Aerospace Development in Taiwan, and its exit doors from Chengdu Aircraft in China. Those suppliers in turn assemble their products from parts made by other suppliers. For its most recent airplane, the so-called 787 "dreamliner", Boeing reportedly communicates directly with 30 different tier-1 suppliers across the globe, and the full supply coordination involves partners in 135 locations.

Global supply arrangements are forming at different speeds around the world. Robert C. Johnson and Guillermo Noguera (2012*a*) document that, on a worldwide average, today less than three-quarters of exports stem from the countries' own value added. The remainder is due to intermediate inputs from other countries. There is considerable variation between regions. The homemade value of a dollar of products exported from an East Asian country is only about 66 cents. In contrast, the figure is 84 cents for North and South America. In this regard, long supply chains appear to be especially important for Asia's exports. In other words, a lot of the value of an East Asian country's products is added in another country, which may be in East Asia or elsewhere. If the formation of global supply chains is indeed akin to another industrial revolution, its progress will depend on an economy's logistical integration with the rest of the world and the spread of communication technology. Geographic proximity to existing manufacturing supply chains facilitates a region's participation in intermediate-input trade. Asia's head start in building manufacturing supply networks will bind the region's exports more closely together than elsewhere. For services supply chains, geographic proximity will matter less, and the expansion of modern communication infrastructure can arguably propel economies into distant supply chains.

Summary

A novel and vital characteristic of recent globalization is the emergence of global supply chains and the offshore production of intermediate inputs. The production process from scratch to final good is now frequently broken into globally dispersed stages. The possibility of shifting production stages across country borders offers a new rationale as to *why economies globalize*.

Offshoring demands that we rethink how products are made in our theory. Manufacturers now contract production factors at a distance, and workers of varying skill levels contribute specific tasks to the production of the final good from afar. One can think of contracting labor from abroad as virtual migration. If globalization already involves the trade of final goods, then virtual (or physical) migration has no effect on earnings because global goods prices determine the wage in every economy. However, two features of real-world global supply chains invalidate the idea that offshoring would have no effect on incomes. These two features also help explain *how economies globalize*.

First, the intermediate production stages vary in factor intensities and especially in the skills they require. If the home economy is more abundantly endowed with high-skilled labor, then high-skill intensive intermediate production stages locate there, while low-skill intensive intermediate production stages shift offshore. This process raises skill demand in *both* economies because the average skill intensity of the production stages increases everywhere. As a result, earnings inequality increases in every country.

Second, intermediate tasks vary in terms of how easily and cost effectively they can be offshored. When work steps are routine and instructions can be written down to clearly spell out what needs to be done, then it costs little to contract the tasks offshore. If the onshore industries get to perfectly price discriminate the contracting costs they pay for each offshored task, then cost savings arise. In perfectly competitive product markets, the savings accrue to the offshorable production workers who remain onshore but now perform the hard-to-offshore tasks. These workers earn higher wages after specializing in the hard-to-offshore tasks. As a result, when offshoring involves trade in tasks with varying contracting costs, then the worker group that is most susceptible to offshoring *gains* from offshoring. The different predictions of these offshoring models renders it unclear which workers should fear offshoring and which workers should not.

Should economies globalize their supply chains? All participating economies gain from specialization along the value chain. However, much work remains for empirical researchers to sort out the evidence and see who can expect to receive the gains.

Global supply arrangements can take various forms. Two specific arrangements are sequential supply chains, as we observe them in global coffee trade, and dispersed supply rings, for which aircraft is a good example. In a sequential supply chain, one essential ingredient such as the coffee bean undergoes a series of transformations until it is made into a final product. In a production arrangement with dispersed supply rings there is no single essential ingredient that gradually gets transformed. In contrast, the final product, the airplane say, emerges from the center of an inner ring (or tier-1) of multiple inputs. Each one of those inputs in turn emerges from a preceding ring of earlier inputs (tier-2), and so forth. The nature of specific supply arrangements expectedly determines how future globalization will vary from industry to industry.

Key Terms

Takeaway	Description, Formula or Graph	Where to Go
Value added	The value of an output less the value of its intermediate inputs. (the production factors labor, land and capital create value added and are paid out of value added; capital receives the remainder after subtracting the wage bill and land rent from value added.)	
Homemade value added	The value of an output less the value of its foreign-sourced intermediate inputs. (The part of value added created by production factors at home.)	
Global supply chain	A supply chain dispersed across countries. The supply chain is a production process in stages. One stage provides the intermediate inputs to the next stage, up to the final assembly of a product.	
Offshoring	The procurement of intermediate inputs from abroad.	
Outsourcing	The shift of a production stage from within a firm (in-house) to a separate supplier (arm's length).	
Virtual migration	A way of looking at offshoring whereby contracting foreign labor from a distance is no more costly than hiring workers domestically.	
Rybczynski Theorem	A proposition in classic trade theory (for two factors, two goods, and two countries) that holds that an increase of one factor's endowment raises the output of the industry that relatively intensely uses the factor, and reduces the output of the other industry, under free final-goods trade and incomplete specialization. Product prices, factor prices, and factor intensities remain unchanged.	
Production stages	Production stages s are characterized by skill intensity $H(s)/L(s)$ and ranked from lowest to highest; below a unique H/L threshold, all stages are offshored.	
Trade in tasks	A specific form of offshoring whereby the contracting costs for intermediate production steps abroad vary with the nature of the contracted tasks.	

Takeaway	Description, Formula or Graph	Where to Go
TFP	Total factor productivity. A multiplier that scales up the production function as a whole, raising the efficiency of all factors of production jointly. A change in the TFP parameter is called *Hicks neutral* technological change.	
Wage gap	Cross-country wage ratio: $\omega = w_L/w_L^* = w_H/w_H^* = A/A^* > 1$	
Offshoring cost	Offshoring cost schedule ranks tasks j from lowest to highest offshoring cost (example $\tau(j) = \tau_0 + \tau \cdot j$); below unique cutoff task J, all tasks are offshored.	
Sequential supply chain	A supply chain in which one essential ingredient undergoes a series of transformations until it is made into the final product. Coffee is an example.	
Dispersed supply rings	A supply chain in which the final product emerges from a ring (tier) of inputs, which in turn emerge from preceding rings (tiers) of inputs. There is no single essential ingredient. The production stages are centers of rings and combine inputs from the ring, which in turn hosts centers of further rings of preceding production stages. The airplane is an example.	

Assessments

Concept checks

Global integration of production

C1.1. Why is it plausible that different authors refer to the same phenomenon of offshoring as global *integration of production* or *disintegration of production*?

C1.2. Is the production of components in foreign countries for later domestic assembly an example of outsourcing? Is contracting with a company to produce the components at home for later foreign assembly unambiguous outsourcing? Is the production of components at home for later foreign assembly an example of offshoring, and if so for which economy?

C1.3. For every dollar of exports shipped to the offshore economy, the home country uses 50 cents in intermediate inputs imported from the offshore economy. The offshore economy, in turn, produces 50 percent of its shipments to the home economy using intermediate inputs purchased from that economy. What is the value-added share of the offshore economy's exports? What is the value-added share of the home economy's exports?

C1.4. For every dollar of exports shipped to the offshore economy, the home country uses 50 cents in intermediate inputs imported from that economy. However, the homemade value added of the exports is 67 cents per dollar. How can this be?

Offshoring of production stages

C2.1. Explain how offshoring intermediate production stages that require different skill levels can simultaneously increase the demand for relatively more skilled workers both onshore and offshore.

C2.2. Offshoring affects the distribution of incomes within trading countries. Explain if and how offshoring may overturn the *Stolper-Samuelson Theorem* that you know from trade in final goods.

C2.3. There are two countries, North (no asterisk) and South (asterisk), and a continuum of intermediate production stages. The production stages are ordered by their skill intensity—that is, the extent to which they require high-skilled labor versus low-skilled labor, or H/L, as depicted in Figure 6.4A. The relative wage paid in the South makes the South a preferable location for certain production stages. Depict the range of intermediate production stages offshored to the South, and depict the range of intermediate production stages located in the North under the current threshold. Depict the average relative employment of H^*/L^* in the South and the average relative employment of H/L in the North. Now suppose the cost of doing business in the South drops. Depict the position of the new threshold. Depict the average relative employment of H^*/L^* in the South and the average relative employment of H/L in the North given the new threshold. Does income inequality fall or increase in the South? Does income inequality fall or increase in the North? Why?

C2.4. Consider the range of production activities as depicted in Figure 6.4D, ordered from zero to one by their skill intensity, where 0 is the least skill intensive and 1 is the most skill intensive activity. Some production stages, up to a certain threshold, are offshored and performed in developing countries. The remainder are performed in developed, onshore economies. Suppose the cost of production in the onshore economies increases. How does the offshoring threshold shift? What happens to the average skill intensity in *offshore* production? What happens to the average skill intensity in *onshore* economies? How does the wage ratio between skilled and unskilled labor change in the *offshore* economy? How does it change in the *onshore* economy?

Trade in tasks

C3.1. There is only a single production stage but offshore labor can be contracted with trade in tasks. Trade in tasks affects the distribution of incomes within trading countries. Explain whether, and how, trade in tasks may overturn the *Stolper-Samuelson Theorem* that you know from trade in final goods.

C3.2. There are two economies, Onshore (no asterisk) and Offshore (asterisk). In each of the economies, there are two industries, X and Y, and there are two factors of production: land T (earning a land rent r) and labor L (earning a wage w). Some of the labor tasks can be offshored. The T-factor (land) cannot be offshored. There is free trade in final goods as in the Heckscher-Ohlin model. Suppose the onshore economy is more productive than the offshore economy by a factor of $A/A^* > 1$. There is no offshoring initially. How does the cross-country wage ratio $\omega = w/w^*$ relate to A/A^*? How does the cross-country land rental ratio r/r^* relate to A/A^*? What are the profits of producers in industries X and Y? When contracted offshore, a task j costs $\tau(j)$.

The tasks are ordered by their offshoring costs $\tau(j)$ from $j = 0$ to $j = 1$ so that $\tau(j)$ increases with j. Suppose once offshoring costs drop, J tasks are being offshored. Use the diagram in Figure 6.5E to answer the following questions. How does the wage w relate to $w^*\tau(j)$ for all j below J? How does the wage w relate to $w^*\tau(J)$ for task J? After offshoring, what are the profits of producers in industries X and Y? After offshoring, how do r, r^* and w^* change if there is free trade in final goods? After offshoring, how does w change if there is free trade in final goods? Why?

C3.3. There are two economies, Onshore (no asterisk) and Offshore (asterisk). Each economy has two industries, X and Y, and two factors of production: land, T (earning a land rent r) and labor L (earning a wage w). Some labor tasks can be offshored. The T-factor (land) cannot be offshored. There is free trade in final goods as in the Heckscher-Ohlin model. Suppose the onshore economy is more productive than the offshore economy by a factor of $A/A^* > 1$. When contracted offshore, a task j costs $\tau(j)$. The tasks are ordered by their offshoring costs $\tau(j)$ from $j = 0$ to $j = 1$ and $\tau(j) = \tau_0 + \tau \cdot j$. Suppose that J tasks are being offshored. What is J in terms of $\omega = A/A^*$, τ_0 and τ? Use the diagram in Figure 6.5E to answer the following questions. Suppose $\tau_0 > 1$. Suppose the offshore economy experiences a productivity shock—that is, it experiences faster total factor productivity growth than the home economy does. Consequently, the productivity gap between the two economies, A/A^*, narrows. What happens to the pattern of tasks traded and the cutoff task, J? What is the range of tasks traded when the productivity gap closes so that $A = A^*$? What are the profits of producers in industries X and Y before and after the productivity shock? How do r, r^*, w^* and w change if there is free trade in final goods?

C3.4. There are two economies, Onshore (no asterisk) and Offshore (asterisk). In each of these two economies there are two industries X and Y, and there are two factors of production: land T (earning a land rent r) and labor L (earning a wage w). Some of the labor tasks can be offshored. The T-factor (land) cannot be offshored. There is free trade in final goods as in the Heckscher-Ohlin model. Industry X is land intensive and industry Y is labor intensive. Suppose the onshore economy is more productive than the offshore economy by a factor of $A/A^* > 1$. When contracted offshore, a task j costs $\tau(j) = \tau_0 + \tau \cdot j$. Suppose J tasks are being offshored. Use the diagram in Figure 6.5E to answer the following questions. Consider a terms-of-trade shock that increases the relative price of goods sold by the X industry so that P_X/P_Y rises. Recall the Stolper-Samuelson Theorem and infer what happens to the wage-rental ratio w/r in the onshore economy and to w^*/r^* in the offshore economy. What happens to the cross-country wage gap $\omega = w/w^*$? What happens to the pattern of task trade and the cutoff task J? How do cost-savings from offshoring change with the terms-of-trade shock? What are the profits of producers in industries X and Y before and after the terms-of-trade shock?

Global supply chains

C4.1. Discuss the distinctive characteristics of sequential supply chains versus dispersed supply rings. How can value added be tracked in a sequential supply chain? How can value added be tracked across dispersed supply rings? Statistical agencies track the shipments of output from one industry to another, or an industry to itself, with so-called input-output matrices. These input-output matrices show that a considerable fraction of most industry's output gets reused as an intermediate input into the same industry's production. Can this production-for-self occur in a sequential supply chain? Can it occur in a dispersed supply rings?

C4.2. List three reasons why world markets for agricultural products are different from the world markets for manufactured products. Offer economic policies that could alleviate or remove the challenges agricultural economies face in terms of capturing more of the value added to products.

C4.3. How do you expect the skill intensities of intermediate production stages and the offshoring costs of various tasks to affect the evolution of the coffee supply chain and the evolution of dispersed supply rings in the aircraft manufacturing industry? How do you expect geographic proximity and communication costs to affect sequential supply chains and dispersed supply rings across the world?

Discussion questions

Q.1. Be warned, this is a mathematical question. It follows up on the two concept checks C1.3 and C1.4, and illustrates the approximate computations for the homemade value added to exports. There are two countries, each of them exports 1 unit of a unique product to the other country and acquires a fraction $\mu < 1$ of its exports as an intermediate input from the other country. Suppose the supply chain is infinitely long because the countries ping-pong intermediate inputs back and forth to each other repeatedly. Explain why, looking only at the final production stage, each country has a share $1-\mu$ of homemade value-added in its exports. Look one stage back, and the share really is $1 - \mu(1-\mu)$. Look two stages back and the share really is $1 - \mu[1 - \mu(1-\mu)]$, and so forth. Show that the infinite ping-pong game results in value added equal to the infinite sum $1 - \mu + \mu^2 - \mu^3 + \ldots = \sum_{n=0}^{\infty}(-1)^n\mu^n$. Go to URL *http://www.wolframalpha.com/input/?i=geometric+series* and have the web page compute the solution of this geometric series for you. (If you prefer to work out the solution yourself, show that the infinite sum can be rewritten compactly as $(1-\mu)\sum_{n=0}^{\infty}\mu^{2n}$. The known solution to the summation term is $\sum_{n=0}^{\infty}\mu^{2n} = 1/(1-\mu^2)$.) Does the country's share of homemade value added account for all of the preceding stages. Is this value larger or smaller than if you account for the final stage only? If so, by how much?

Q.2. There are two economies, Onshore (no asterisk) and Offshore (asterisk). Each economy is endowed with two factors of production: skilled labor H and unskilled labor L. There is a continuum of production stages. The production stages s are ordered by their relative skill intensity, $H(s)/L(s)$ from $s = 0$ to $s = 1$ so that $H(s)/L(s)$ increases with s. Depict an $H(s)/L(s)$ schedule for this scenario using the diagram in Figure 6.4B. Suppose there is a unique offshoring threshold as shown in Figure 6.4B. Depict the average $H(s)/L(s)$ intensities of offshore production and of onshore production. Suppose factor prices do not equalize around the world. All else equal, which economy has a higher wage ratio w_H/w_L (w^*_H/w^*_L)? Suppose the threshold shifts so that more production stages are performed offshore in the new equilibrium. Depict the new offshoring threshold and the new average $H(s)/L(s)$ intensities of offshore production and of onshore production. After the shift in the offshoring threshold, how do the wage ratios w_H/w_L and w^*_H/w^*_L change?

Q.3. There are two regions, North (no asterisk) and South (asterisk), and many intermediate production stages. The production stages are ordered by their skill intensity, H/L, as depicted along the horizontal axis in the graph of Figure 6.4C. Offshoring tasks to the South is preferable below the threshold. Production in the North is preferable above the threshold. Depict the range of production stages offshored to the South, and depict the range of production stages located in the North under the shown threshold. Depict the average relative employment of H^S/L^S in the South and the average relative employment of H^N/L^N in the North. Now suppose offshoring costs increase and fewer production stages are offshored to the South. Depict the position of the new threshold. Depict the average relative employment of $(H^S/L^S)'$ in the South and the average relative employment of $(H^N/L^N)'$ in the North under the new threshold. Does income inequality fall or increase in the South? Does income inequality fall or increase in the North?

Q.4. There are two economies, Onshore (no asterisk) and Offshore (asterisk). Each economy has two industries, X and Y, and two factors of production: land T (earning a land rent r) and labor L (earning a wage w). Some labor tasks can be offshored. The T-factor (land) cannot be offshored. There is free trade in final goods as in the Heckscher-Ohlin model. Suppose the onshore economy is more productive than the offshore economy by a factor of $A/A^* > 1$. When contracted offshore, a task j costs $\tau(j)$. The tasks are ordered by their offshoring costs $\tau(j)$ from $j = 0$ to $j = 1$ so that $\tau(j)$ increases with j. In the initial equilibrium, J tasks are being offshored. How does the wage w relate to $w^*\tau(j)$ for all j below J? How does the wage w relate to $w^*\tau(J)$ for task J? After offshoring, what are the profits of the producers in industries X and Y? Now suppose the offshoring cost schedule changes to $\tau'(j)$ as depicted in Figure 6.5G. The cutoff task remains unchanged at $J' = J$. What are the profits of producers in industries X and Y now? After the change in offshoring costs, how do r, r^*, and w^* change if there is free trade in final goods? After the change in offshoring costs, how does w change if there is free trade in final goods? Why?

Q.5. There are two economies, Onshore (no asterisk) and Offshore (asterisk). Each economy has two industries, X and Y, and two factors of production: land T and labor L. Some labor tasks can be offshored. The T-factor (land) cannot be offshored. There is free trade in final goods as in the Heckscher-Ohlin model. Suppose the onshore economy is more productive than the offshore economy by a factor of $A/A^* > 1$. When contracted offshore, a task, j, costs $\tau(j)$. The tasks are ordered by their offshoring costs $\tau(j)$ from $j = 0$ to $j = 1$ so that $\tau(j)$ weakly increases with j, as the step function in Figure 6.5F shows. In the initial equilibrium, J tasks are being offshored. Now suppose the cross-country wage gap $\omega = A/A^*$ widens. When the ω line moves off a horizontal segment of the $\tau(j)$ step function, does the cutoff task change? Do r, r^*, and w^* change if there is free trade in final goods? Does w change if there is free trade in final goods? When the ω line moves along a vertical segment of the $\tau(j)$ step function, does the cutoff task change? Do r, r^*, and w^* change if there is free trade in final goods? Does w change if there is free trade in final goods?

Data exercises

E.1. Consider the Theil index of global income inequality and its between and within decompositions by Bourguignon and Morrisson (2002), as depicted in Figure 6.5H. Evaluate whether the following statements about trade theory are true, false, or indeterminate. Explain your answer. (1) Classic trade models (Ricardian or Heckscher-Ohlin) explain the increase in income inequality *between* countries during the first era of globalization (from 1880 to 1950). (2) The Heckscher-Ohlin model explains the drop in inequality *within* countries during the period of de-globalization (between the World Wars) if high-skill abundant countries have a greater share of the world's income. (3) The Heckscher-Ohlin model explains the small increase in inequality *within* countries during the second era of globalization (from 1950 to 1990) if high-skill abundant countries have a greater share world's income. (4) Offshoring of intermediate production stages explains the small increase in inequality *within* countries during the second era of globalization (from 1950 to 1990).

Further Readings

Autor, David H., Frank Levy, and Richard J. Murnane. 2003. "The Skill Content of Recent Technological Change: An Empirical Exploration." *Quarterly Journal of Economics*, 118(4): 1279–1333.

Blinder, Alan S. 2006. "Offshoring: The Next Industrial Revolution?" *Foreign Affairs*, 85(2): 113–28.

Feenstra, Robert C., and Gordon H. Hanson. 1996. "Foreign Investment, Outsourcing and Relative Wages." In *The Political Economy of Trade Policy: Papers in Honor of Jagdish Bhagwati*, ed. Robert C. Feenstra, Gene M. Grossman and Douglas A. Irwin, Chapter 6, 89–127. Cambridge and London: MIT Press.

Feenstra, Robert C., and Gordon H. Hanson. 1999. "The Impact of Outsourcing and High-Technology Capital on Wages: Estimates for the United States, 1979-1990." *Quarterly Journal of Economics*, 114(3): 907–40.

Daviron, Benoit, and Stefano Ponte. 2005. *The Coffee Paradox: Global markets, commodity trade and the elusive promise of development.* London: Zed Books.

Grossman, Gene M., and Esteban Rossi-Hansberg. 2008. "Trading Tasks: A Simple Theory of Offshoring." *American Economic Review*, 98(5): 1978–97.

Johnson, Robert C., and Guillermo Noguera. 2012*a*. "Accounting for Intermediates: Production Sharing and Trade in Value Added." *Journal of International Economics*, 86(2): 224–36.

Johnson, Robert C., and Guillermo Noguera. 2012*b*. "Proximity and Production Fragmentation." *American Economic Review*, 102(3): 407–11.

Jones, Ronald W., and Henryk Kierzkowski. 1990. "The Role of Services in Production and International Trade: A Theoretical Framework." In *The political economy of international trade: Essays in honor of Robert E. Baldwin*, ed. Ronald W. Jones and Anne O. Krueger, Chapter 3, 31–48. Oxford and Cambridge, Mass.: Blackwell.

Koopman, Robert, William Powers, Zhi Wang, and Shang Jin Wei. 2010. "Give Credit Where Credit Is Due: Tracing Value Added in Global Production Chains." *NBER Working Paper*, 16426.

Rybczynski, T. M. 1955. "Factor Endowment and Relative Commodity Prices." *Economica*, 22(88): 336–341.

Yi, Kei Mu. 2003. "Can Vertical Specialization Explain the Growth of World Trade?" *Journal of Political Economy*, 111(1): 52–102.

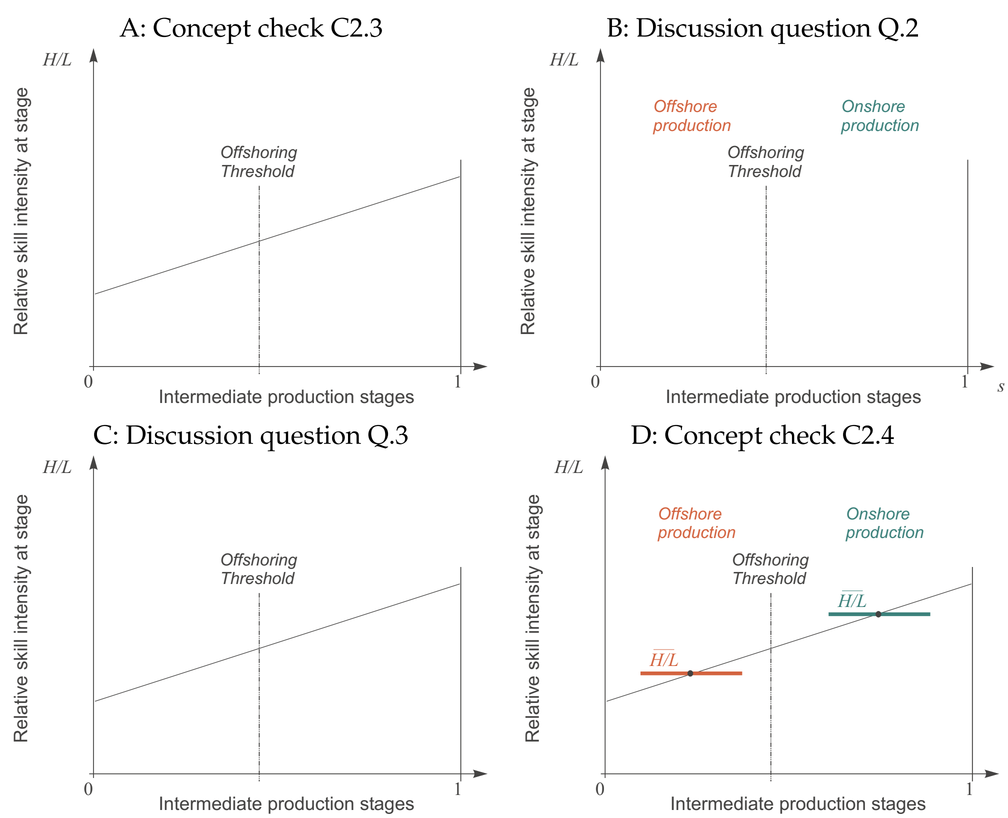


Figure 6.4: Graphs Accompanying Concept Checks and Discussion Questions

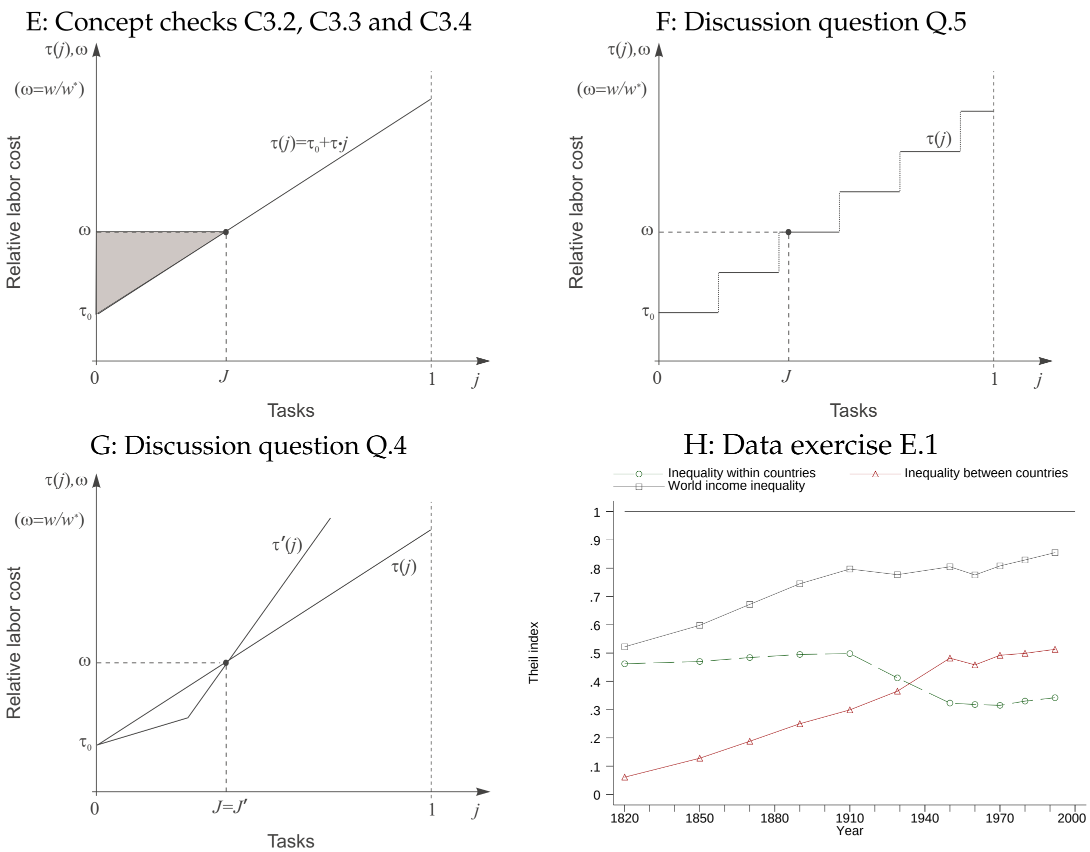


Figure 6.5: Graphs Accompanying Concept Checks and Discussion Questions

Mathematical Appendix 6.I: *Unique Treshold in the Feenstra-Hanson Model*

There is a unique threshold production stage in the Feenstra-Hanson model. All production stages below the threshold locate offshore. Above the threshold, all production stages are onshore.

Let's start with an intuitive explanation. If a stage with a skill intensity ratio $H(s)/L(s)$ is kept onshore, it cannot be the case that a stage with an even higher skill intensity and thus even higher relative labor cost move offshore, where high skills are even more expensive to hire. Similarly, if a stage with low-skill intensity is moved offshore, it cannot be the case that an even less-skill intensive stage is back onshore because the cost of the intermediate input would be even higher at home where low skills are expensive to hire. The left panel of Figure 6.1 depicts the threshold and the initial equilibrium. In the initial equilibrium, some offshoring has already taken place. The production stages to the left of the threshold are located offshore. The production stages to the right of the threshold are located onshore.

Now the math. The production cost of one unit of an intermediate input at stage s is

$$c(s) = w_H a_H(s) + w_L a_L(s) \qquad \text{and} \qquad c^*(s) = \bar{\tau} w_H^* a_H(s) + \bar{\tau} w_L^* a_L(s),$$

onshore (no asterisk) and offshore (asterisk), under our assumption that high-skilled and low-skilled labor enters in fixed proportions. The parameters $a_H(s)$ and $a_L(s)$ are the unit labor requirements of high-skilled workers and low-skilled workers. (Microeconomists call the underlying production function a Leontief production function, for which output $M(s)$ at each intermediate production stage s is $M(s) = \min\{H(s)/a_H(s), L(s)/a_L(s)\}$.) The variable $\bar{\tau}$ denotes the cost of doing business in the offshore economy, which assemblers in the home and foreign economies have to pay when they procure intermediate inputs from the offshore economy. The offshoring cost $\bar{\tau}$ is constant and does not differ for tasks.

Recall the assumption that the onshore economy relatively more abundantly endowed with high-skilled labor, so the relative wage of high skilled workers is lower at home than offshore:

$$w_H/w_L < w_H^*/w_L^*.$$

As a consequence, the production cost of one unit of an intermediate input goes up strongly in the offshore economy where w_H^*/w_L^* is high. In contrast, the cost of an intermediate input increases more slowly in the onshore economy because w_H/w_L is relatively low. The left panel of Figure 6.6 depicts the production cost by stage s in the two economies. Assemblers in both economies consider the cost differences. It is optimal for them to purchase from offshore all of the intermediate inputs $\underline{s}$ for which $c^*(\underline{s}) < c(\underline{s})$. Assemblers buy from the onshore economy production stages all the intermediate inputs $\overline{s}$ for which $c^*(\overline{s}) \geq c(\overline{s})$. This implies that there is a unique threshold of skill intensity $\hat{s}$ below which intermediate inputs are sourced from offshore and above which intermediate inputs are source from onshore. At the threshold $\hat{s}$

$$c^*(\hat{s}) = c(\hat{s}).$$

As the right panel of Figure 6.6 shows, the threshold $\hat{s}$ shifts to the right when $\bar{\tau}$ drops and $c^*(s)$ falls for every s.

Mathematical Appendix 6.II: *General Offshoring Cost Schedule for Task Trade*

Recall our task-trade discussion from section 6.3. In this appendix we make one change: We adopt a more general offshoring cost function $\tau(j)$ that weakly increases in j. Weakly increasing means $\tau(j)$

can have flat parts where the offshoring cost does not change for a range of tasks but $\tau(j)$ must not decline at any point. The only offshorable production factor is H as in the main text.

As explained in footnote 4 before, we can tie the wage gap to a productivity difference between the onshore and offshore economies. Suppose industries located in the home country produce output under a total factor productivity (TFP) multiplier A like in Chapter 5. The foreign country, in contrast, only has a small TFP booster $A^* < A$. Under this generalization, all main theorems but one continue to hold. (The Heckscher-Ohlin Theorem, the Stolper-Samuelson Theorem and the Rybczynski Theorem hold unaltered.) One theorem becomes more general: there is now *conditional factor price equalization*. As a result, the cross-country wage gap becomes $\omega = w_L/w_L^* = w_H/w_H^* = A/A^* > 1$.

If the home wage exceeds the foreign wage times the contracting cost multiplier, then the task is cheaper to perform offshore. An industry will optimally stop foreign contracting at a cutoff task J where

$$\tau(J)w_H^* = w_H.$$

At the task J, each onshore industry is indifferent between using contract labor from offshore at cost $\tau(J)w_H^*$ or from onshore at cost w_H. The left panel of Figure 6.2 depicts the optimal stopping point for offshoring at the cutoff task J. Using the cross-country wage gap $\omega = w_H/w_H^* = A/A^*$ to rewrite the optimal foreign contracting rule, the last task to offshore J is the one whose individual cost $\tau(J)$ satisfies

$$\omega = \tau(J).$$

Below the cutoff task J, it is less costly to contract tasks from abroad than at home. Above the threshold, it is less costly to employ domestic labor. The left panel of Figure 6.2 depicts this initial equilibrium. In the initial equilibrium, some offshoring has already taken place. The range of tasks to the left of J is performed offshore.

Suppose offshoring costs further drop for all tasks. That is, the $\tau(j)$ schedule falls to $\tau'(j)$, and $\tau'(j) < \tau(j)$ for all tasks. How does J change? As the right panel of Figure 6.7 shows, the optimal stopping point for offshoring J shifts to the right to a level J'. The range of tasks between the former cutoff task J and the new threshold J' is being offshored as well. These tasks used to be performed by domestic H workers. Now these tasks are contracted from abroad and performed by H^* workers. Every foreign low-skilled worker receives a wage w_H^*. But the domestic industry does not pay a constant cost for each offshored task. To the contrary, for the very first offshored task, each home industry pays only $\tau(0)w_H^* < w_H$. For the last offshored task it pays much more: $\tau(J')w_H^* = w_H$. Each onshore industry gets to perfectly price discriminate, task by task, the cost it has to incur and pays less than w_H for all the tasks below J'. This generates cost savings for each home industry (or what microeconomists typically call a quasi rent). The cost savings is depicted by the grey-shaded area in the right panel of Figure 6.7.

In each industry i, the last task J to be offshored satisfies the condition that the wage savings just balance offshoring costs $w_H = \tau(J)w_H^*$. Under perfect competition, there are no profits, so each onshore industry i receives a product price p_i that exactly equals the unit cost. What is the unit cost? An industry i optimally hires L workers at a unit labor cost of $w_L\, a_{Li}$, plus H workers for the range of $1-J$ tasks at a unit labor cost of $w_H\, a_{Hi}$, and finally foreign H^* workers for the range of J tasks at a unit labor cost of $w_H^*\, a_{Hi}$ times the total offshoring cost for them. What are the total offshoring cost for these J tasks? The total offshoring cost is the area below the $\tau(j)$ curve between zero and J. Equivalently, the total offshoring cost can be computed as the rectangular area of relative wage payments $\omega \cdot J$ less the total cost savings benefit of $B(J)$, and the total cost savings benefit is the area below the ω line and above the $\tau(j)$ curve between zero and J. (The precise area of the total cost savings benefit is $B(J) = \int_0^J [\omega - \tau(j)]\,\mathrm{d}j$, but we will not really need that integral.)

With the unit cost complete, we can state

$$\begin{aligned} p_i &= w_L\, a_{Li} + (1-J)\, w_H\, a_{Hi} + [\omega J - B(J)]\, w_H^*\, a_{Hi} \\ &= w_L\, a_{Li} + w_H\, a_{Hi} - w_H^*\, a_{Hi}\, B(J), \\ &= w_L\, a_{Li} + w_H\, [1 - B(J)/\omega]\, a_{Hi}, \end{aligned}$$

where a_{Li} and a_{Hi} are the unit factor requirements to make one good in industry i and $B(J)$ is the total cost savings benefit. The first equality sets the price equal to the sum of the unit labor cost for L, plus the unit labor cost for the $1-J$ tasks performed by H, plus the unit labor cost for the J tasks performed by offshore H^* labor. The second equality follows after plucking the optimality condition $w_H/w_H^* = \tau(J)$ into the first equality. The third equality follows from collecting terms and using the constant $\omega = w_H/w_H^*$ to simplify.

The unit factor requirements a_{Li} and a_{Hi} do not change under Heckscher-Ohlin trade in final goods as long as the factor price ratio w_H/w_L stays constant. The factor price ratio w_H/w_L in turn remains fixed as long as there is incomplete specialization under free final-goods trade. Therefore the unit labor requirements $a_{Hi}(H_i/L_i)$ and $a_{Li}(H_i/L_i)$ are also constant.

Suppose the $\tau(j)$ schedule falls to $\tau'(j)$ so that J increases, as depicted in the right panel of Figure 6.2. It is apparent from the graph that the cost savings benefit $B(J)$ increases with the drop in $\tau(j)$.[5] As a consequence, the term $[1 - B(J)/\omega]$ falls with more offshoring. The cost savings from offshoring act in a similar way as a drop in the marginal unit labor requirement a_{Hi} or a productivity increase of a_{Hi}. As discussed in the text, however, there is no physical change in productivity. Perfect price discrimination of contracting the tasks generates a quasi rent.

What else can change in the second equation? For the foreign country, which cannot offshore under $A/A^* > 1$, product prices $p_i = w_H^*\, a_{Hi}^* + w_L^*\, a_{Li}^*$ determine the factor prices so that both w_L^* and w_H^* stay the same as before offshoring. If w_L^* stays the same, then w_L must remain fixed at $w_L = (A/A^*)w_L^*$. Similarly, the product $[1-B(J)/\omega]\cdot w_H = (A/A^*)w_H^*$ must remain constant for given a_{Hi}. We conclude that w_H must increase by the same percentage as the preceding term $[1 - B(J)/\omega]$ falls. The term $B(J)$ measures the cost savings generated as we move J up. When $J = 0$, then $B(J) = 0$, so that there is no cost savings. We are then back in the conventional Heckscher-Ohlin model with $p_i = w_L\, a_{Li} + w_H\, a_{Hi}$.

[5] To see this more rigorously, suppose the offshoring cost schedule depends on a parameter β that changes its level or slope, or both: $\tau(j;\beta)$. With some math, namely a total differential and Leibnitz's rule, one can show that the marginal change of $B(J;\beta)$ from percentage changes in J and β is $\mathrm{d}B = J[\omega - \tau(J;\beta)]\hat{J} - \beta\{\int_0^J [\partial\tau(j;\beta)/\partial\beta]\,\mathrm{d}j\}\hat{\beta}$, where hats denote percentage changes and the first term $\omega - \tau(J) = 0$ goes away by the nature of the cutoff task. For a percentage change of $\hat{\beta} > 0$ that reduces τ so that $\partial\tau(j;\beta)/\partial\beta < 0$ the cost savings benefit $B(J;\beta)$ increases, $\mathrm{d}B > 0$.

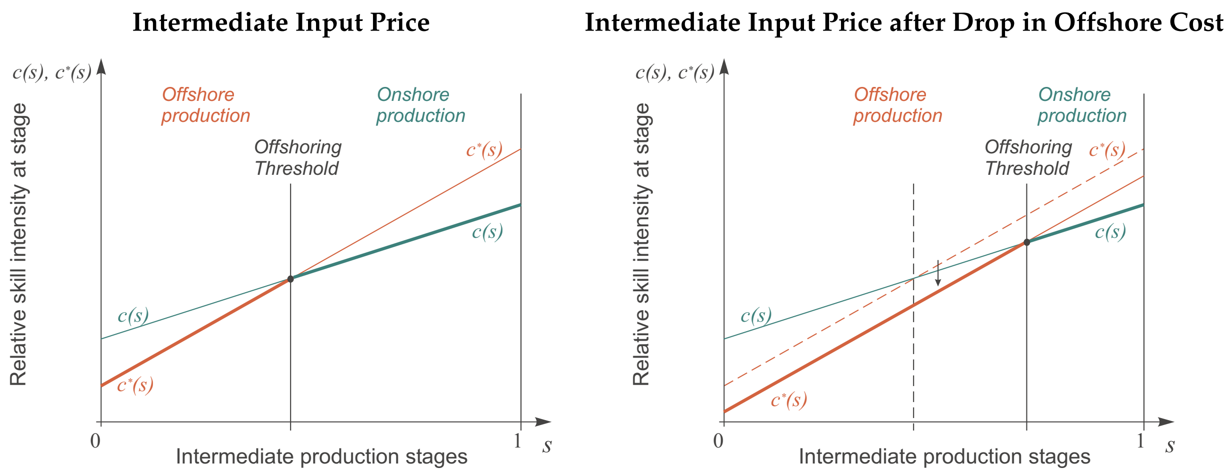


Figure 6.6: Onshore and Offshore Price of Intermediate Inputs

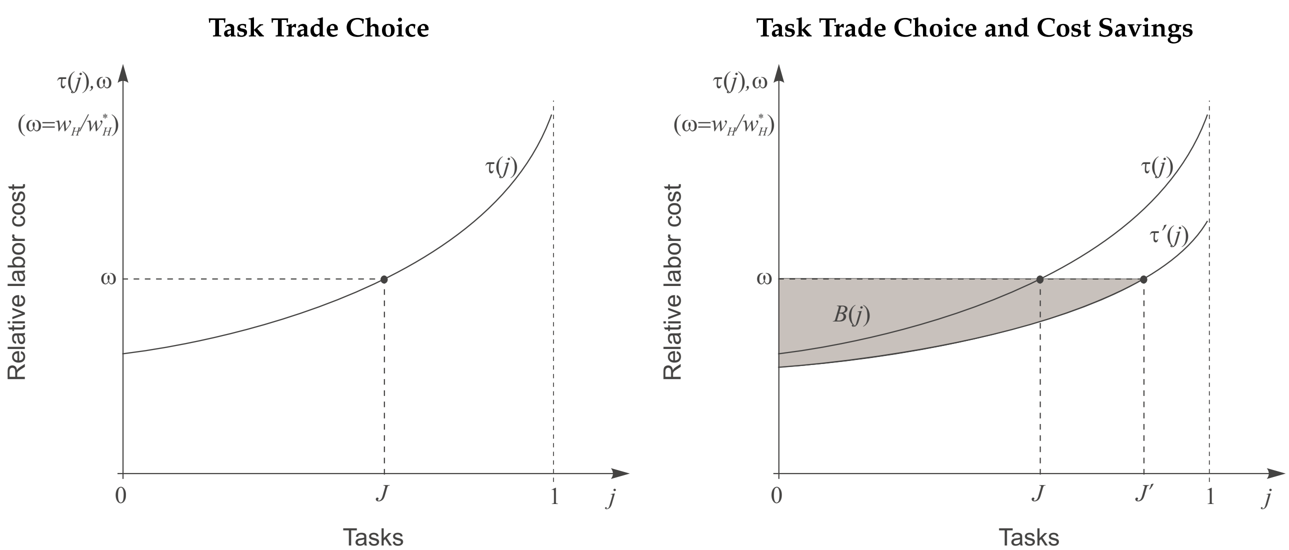


Figure 6.7: Trade in Tasks under Non-linear Offshoring Cost