Globalization, heterogeneity, and imperfect information
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Chapter 6

Trade Liberalization and Labor Market Dynamics

6.1 Introduction

It is well known that import tariffs distort both the consumption and the production side of the market. However, when trade liberalization increases income inequality and unemployment, the support for liberalization programs may decrease unless instruments are included in the liberalization package that try to limit these adverse effects. In this chapter we will focus on the dynamic labor market effects of trade reform by taking an explicit look at worker heterogeneity, imperfect information, and the potential for short-run increases in unemployment to become persistent. Our model has general validity to study reallocation of workers and jobs after a change in relative prices, although we restrict ourselves to the case where the change in relative prices is due to trade liberalization.

Imagine an economy with two sectors, agriculture and manufacturing, in which a tariff is levied on agricultural imports. The protection from foreign competition raises not only the price of food in the home economy, but also affects relative factor prices in both sectors. Import protection, and its mirror image trade liberalization, influence the allocation of labor in an economy and therefore can be expected to affect employment, production, and the distribution of income. As a consequence, it becomes important to answer the following questions: (a) through what channel, and to what extent, does the import tariff distort the productive potential of the economy?; (b) what happens to job creation in each sector of the economy after the import tariff has been abolished? Moreover, what happens to aggregate unemployment?; i.e. is the manufacturing sector capable of absorbing all the workers that have become redundant in the agricultural
sector after trade has been liberalized?; (c) what is the impact of trade liberalization on the distribution of wages?; and (d) if trade liberalization indeed has some negative side-effects on the labor market, what additional features of a reform package would be necessary to protect employment in the home economy and therefore increase support for, and take full advantage of, trade openness?

These questions have a long history in the international trade literature. In general one can say that the answers to the questions above following from neo-classical theories are as following. The distortionary effect of import protection on the labor market stemmes from the fact that a tariff increases employment in the protected sector. Because of diminishing returns, the productive potential of the economy is hurt. Abolishment of an import tariff in these models sets in motion instantaneous changes in real wages and labor reallocation such that workers flowing in from the formerly protected sector are immediately absorbed in the unprotected sector. On the other hand, models that utilize the concept of short-run wage stickiness do include the potential for trade liberalization to increase short-run unemployment (see Rodrik (1987), Buffie (1984), and Edwards (1988, 1993)).

Concerning the third question, in the specific context of trade models, the standard Ricardian model assumes that labor is the only factor of production and it is assumed to be able to move freely from one sector to the other. As a consequence, every individual is made better of as a result of free trade because trade does not affect the distribution of income (see Krugman and Obstfeld, 1997). Since some factors can move more freely than others in practice, the Ricardian model has been extended to the specific factors model (see Samuelson (1971) and Jones (1971)). Factors of production are assumed to be specific to certain industries, for example land for agriculture and capital for manufactures. In this case, there is an effect of trade reform on the income distribution since specific factors give rise to diminishing returns to labor in each sector.

The last question has a long-history in the first-best literature on tariffs versus alternative instruments to accomplish one's goals. As is well known, a production subsidy is preferable to an import tariff since then the consumption side will no longer be distorted. Such a specific subsidy however, does not alleviate the labor market distortion.

Some of the conclusions we arrive at are similar in spirit to those of standard trade theory. Nevertheless, the models mentioned above do not analyze the potential for any temporary increase in unemployment to become persistent. Also, even in the specific factors model mentioned above, it is still argued that labor is perfectly mobile, which in practice is only true for some worker types (Blanchard and Katz, 1992). As a consequence, these models do not pay sufficient attention to the role of worker heterogeneity in generating sectoral interactions. Additionally, since after trade has been reformed, workers
move from the formerly protected to the unprotected sector, it is plausible to expect that employers to some extent are imperfectly informed about the productivity of the pool of job seekers.

Therefore, this chapter tries to address the labor market implications of trade liberalization in a framework with worker heterogeneity, imperfect information, and where temporary increases in unemployment can become persistent we extend the model by Pissarides (1992). Pissarides shows that if unemployed workers lose some of their skills during unemployment, aggregate employment can exhibit persistence that outlasts both the duration of the shock that moves it from the steady state and the maximum duration of unemployment. In this model sector-specific shocks are the same as aggregate shocks as there is only one sector. Therefore, his model is not concerned with spillover effects of sector-specific shocks, such as trade reform, which arise when labor is (imperfectly) mobile between sectors, but only with the propagation of a rise in the unemployment rate after an aggregate shock. To study these sectoral interactions, we specify a two-sector model in the spirit of Pissarides.

Furthermore, when some workers move out of the agricultural sector and into manufacturing following the abolition of the tariff, it is reasonable to expect that the quality of the pool of job seekers in manufacturing is affected. After all, these workers did work in agriculture for a reason and are perhaps not as productive in manufacturing. After the abolition of the tariff, it will be the 'generalists' that decide to relocate; i.e. the workers that are only slightly more productive in one sector compared to the other will switch first, and this can have important consequences for job reallocation after trade has been reformed. The effect on the expected quality of job seekers, together with their number, in both sectors determines the sectoral employment response after trade reform. Therefore, to study whether the manufacturing sector can absorb the workers formerly producing agricultural goods in a non-trivial manner, we need to account for this possibility of a quality difference. Thus we have to introduce heterogeneity among workers' productivity in the Pissarides model, which we do by utilizing the framework developed by Heckman and Honoré (1990).

Although the latter use a static full-employment model and are mainly concerned with the distribution of earnings, our approaches have a common element: given that workers are heterogeneous and given the fact that each worker's productivity can be different in different sectors, how do workers determine in which sector they are going to search for a job? We follow Heckman and Honoré (1990) by arguing that workers try to exploit their comparative advantage. This allows us to determine the fraction of the population searching for a job in either sector, which also provides the channel through which tariffs
implies efficiency losses.

Other papers with related models are, for example, Blanchard and Katz (1992), and Caplin and Leahy (1993). Blanchard and Katz (1992) set up a model in which different (US) states produce different goods. After a state-specific shock, relative wages and unemployment change which in turn leads to labor mobility across states. They argue that labor mobility is an important mechanism through which the effects of state-specific shocks on employment are mitigated. Caplin and Leahy (1993) show that the interaction between investment and information dynamics has important macroeconomic consequences. In their model, an imbalance between investment and disinvestment is the propagation mechanism through which sectoral shocks may have persistent effects on the aggregate economy. In our case, the assumption that unemployed workers lose part of their skills and the interaction between the ‘quantity’ and ‘quality’ effects of sector-specific shocks form the basis for both the persistence and the propagation mechanism of sector-specific shocks.

Lilien (1982) shows that shifts of labor demand between sectors necessitate continuous labor reallocation. Since it takes time for workers to reallocate between sectors, it becomes hard to disentangle cyclical unemployment from fluctuations in the ‘natural’ rate of unemployment. Mortensen and Pissarides (1994), Blanchard and Diamond (1989), and Abraham and Katz (1986) all try to disentangle these sectoral shifts from common shocks. Under sectoral shifts, rates of job creation and job destruction are presumed to move in the same direction, while common shocks should have divergent effects on these rates.

When one allows for worker heterogeneity, as we do, labor can be divided in one part that is more or less sector-specific (the ‘specialists’) and another part (the ‘generalists’) that is much more flexible. Utilizing our framework with worker heterogeneity, we show that tariffs, by raising wages and employment prospects in the protected sector, affect the comparative advantage of workers which will result in a sub-optimal allocation of generalists over firms. Thus, limiting free trade may not only prevent specialization on the basis of comparative advantage of countries, but also of workers. Modelling heterogeneity allows one to analyze which workers are sector specific and which workers move in response to the abolishment of an import tariff. In this way we are able to determine the effects of trade reform on the productive potential of the economy without incorporating diminishing returns and thus provides a second channel leading to a distortion, operating

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1Jovanovic and Moffitt (1990) also discuss a model in which the origins of labor mobility come from either sectoral shocks or worker-employer mismatch.

2On the importance of job turnover and worker reallocation, see Davis and Haltiwanger (1990).
completely via heterogeneity of workers.

Another effect of trade liberalization comes from the fact that abolishing a tariff can increase short-run unemployment. When workers lose some of their skills during unemployment, the average quality of job seekers decreases. This may in turn provide a channel through which trade liberalization could increase unemployment persistently. In addition, we assume that employers are imperfectly informed about the ability of job applicants. Together with loss of skills this implies aggregate unemployment duration dependence; i.e., the average quality of job seekers is what matters for job creation and the probability of being matched to a job is independent of ones characteristics. Notice that this form of imperfect information is especially relevant in our framework to study the employment consequences in the unprotected sector when workers move in from the protected sector after trade has been liberalized, since it will be difficult for employers to determine the ability of the inflowing outsiders relative to insiders.

Recently, the effects of trade liberalization on wage inequality and unemployment of less-skilled workers has received considerable attention. Although there is no consensus, the majority view seems to be that technology changes, and not trade, is the principal reason behind these labor market trends (see, Albuquerque and Rebelo, 1998). Indeed, one of the conclusions stemming from our model is that one cannot say in general that trade liberalization implies increased income inequality, nor can one say that any unemployment effects will be concentrated among the least-skilled workers. The reason for this result is that, again, firms cannot observe worker quality before hiring, and the quality of the overall (combining both sectors) unemployment pool is invariant to the trade policy except for the fraction of long-term unemployed workers.

The model therefore does not predict that lower skilled workers will be worse off compared to higher skilled workers when international trade is liberalized. What does follow from our model however, is a persistent rise in unemployment after trade liberalization. Also, as we will see, which workers stand to lose most from trade reform does not depend on the distinction between (low and high skilled) individuals, but on the different productivity levels of a single individual with respect to the different sectors of an economy. In a sense, we do not assume that a worker is either high or low skilled, workers can be 'specialists' (being much more productive in one sector than the other) or 'generalists' (being more or less equally productive in both sectors). The latter can be very productive in both sectors or not at all, or somewhere in between. Under this more realistic scenario it becomes hard to make judgements on such broad concepts as the wage distribution between high-ability versus low-ability employees.

Which additional measures should be included in the liberalization package to pre-
vent such a persistent rise in unemployment after trade has been reformed? As in more
traditional models mentioned above, a wage-cost subsidy is preferable to an import tariff
as the consumption side will then no longer be distorted. However, giving the formerly
import protected sector a wage-cost subsidy still distorts the comparative advantage of
workers. We argue that giving both sectors a subsidy can eliminate not only the standard
consumption side distortion, but also the labor market distortion. Moreover, the fact that
the comparative advantage of workers will no longer be distorted also implies that giving
a subsidy to both sectors is cheaper than limiting the wage-cost subsidy to the formerly
protected sector. In the latter case, too many workers search for a job in the agricultural
sector and as a consequence too many jobs will be subsidized.

The rest of this chapter is in five parts. First, Section 6.2 develops the model in steady
state and discusses the productivity costs of tariffs. In Section 6.3 we discuss the effects
of trade reform on employment in each sector and the resulting dynamics of aggregate
employment and unemployment. We present some illustrative simulations in Section
6.4. Then, Section 6.5 considers the effectiveness of including additional measures in the
liberalization package to offset any increase in unemployment while still aiming for optimal
production. Section 6.6 concludes and discusses some applications and implications of our
model. The Appendix contains the derivations of the main mathematical results.

6.2 The Model in Steady State

Workers search for jobs in either agriculture, labelled $x$, or manufacturing, labeled $z$.
These jobs are offered by employers, who are immobile across the sectors. The matching
procedure between job searchers and employers is assumed to be as follows. Every worker
decides at the beginning of each period in which of the two sectors, $x$ or $z$, he will search
for a job. Workers can work in only one sector in any period and can move from one
sector to the other without incurring any costs. Each worker chooses the sector in which
he expects to earn the largest wage given his ability level in each sector. He reports his
choice to the job centre which has two distinct departments for the two sectors. Each
employer inspects the amount and expected quality of the job seekers in his sector. Then
he decides on the number of vacancies to open. Now each department matches the workers
to the vacancies using a particular matching technology. This gives us the steady state
level of employment in each sector.

The model is in discrete time and the dynamics derive from two overlapping genera-
tions of workers, each of which is of fixed size $L$, and a variable number of jobs that last
for one period only. Thus there are a total of $2L$ workers present in the population at
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Each time $t$. In each of the two periods of their life workers are in one of two states, either employed or unemployed. This allows for a division of the workers into two types. The first type is labelled the short term unemployed (stu) workers. This group consists of the new entrants (the young) and the (old) employed workers of the previous period who are still alive today. The second type of workers is labelled the long term unemployed (ltu) workers. This group consists of the (old) workers that were unemployed in the previous period and are still alive today.

For every worker two positive ability levels are drawn from a bivariate lognormal probability distribution $f(.,.)$. We label the means and variances of the underlying marginal normal distributions by $\mu_x$, $u_z$, and $\sigma_{xz}$, $\sigma_{zz}$ respectively and the covariance between ability in sector $x$ and $z$ is labelled $\sigma_{xz}$. Furthermore, we introduce $\sigma^2 = \sigma_{xz} + \sigma_{zz} - 2\sigma_{xz}$. Denote the realizations of $f(.,.)$ for worker $i$ by $\theta_{ix}$ and $\theta_{i\cdot z}$ for sector $x$ and $z$ respectively. We assume that the distribution is independent of the workers' employment record and that the young inherit the ability pair from the old who die. Thus the ability pairs drawn at time $t = 0$ remain present in the population forever after.\(^3\) To get a worker's skill level, the ability of an stu worker is multiplied by 2 and the ability of an ltu worker is multiplied by $2y$ with $0 < y < 1$.\(^4\) Hence, ltu workers are less productive than stu workers. Since the distribution of ability is fixed, workers do not become less able when they have been unemployed. The loss of productivity stems from the fact that we assume that workers who were unemployed in the previous period are less able to transform their ability into output compared to workers who were employed in the former period. In other words, to formalize loss of skills in the easiest way possible, we assume that effective ability of long-term unemployed workers is lower than for short-term unemployed workers.

When a vacancy is filled by an stu worker, say worker $i$, he receives a payoff $\alpha2p_{ix}^j\theta_{ix}^{\cdot \cdot}$, where $p_{ix}^j$ is the given price level in sector $j = x, z$ and $\alpha$ is the fraction of the worker's productivity that accrues to him. This fraction originates from static Nash-bargaining between the worker and the employer. If a vacancy is filled by an ltu worker, the worker receives a payoff $\alpha2yp_{i\cdot z}^j\theta_{i\cdot z}^{\cdot \cdot}$. The expected wage income of a worker in sector $j$ is now equal to his expected payoff when employed multiplied by the expected probability, $E_q_j^i$, that he is actually matched to a vacancy.\(^5\) We assume that workers base their decision to search in one sector or the other on the matching probability at time $t - 1$; i.e. $E_q_j^i = q_{i-1}^j$. We make the same assumption regarding prices, i.e. $E_{p_{ix}^j} = p_{i-1}^j$. Thus we explicitly assume

\(^3\)In a large population this assumption can also be interpreted as drawing new skill levels for each new generation. A large population argument then ensures that the results remain the same.

\(^4\)The factor 2 is introduced for notational convenience only.

\(^5\)As in Pissarides (1992) we assume that $q_j^i$ is not only the average probability that a worker meets a vacancy, but that it is also the actual probability for each worker in sector $j$.
backward-looking (static) expectations. A worker chooses to search for a job in the sector where his expected wage income is the highest. Furthermore we assume $p^x_t = p^z_t$. Suppose that sector $x$ (agriculture) is the import competing sector and sector $z$ is the exporting sector and that an import tariff, $T^x$, is levied such that the domestic price raises to $p^x_t (1 + T^x)$. Worker $i$ will search in sector $x$ at time $t$ if:

$$p^x_{t-1} (1 + T^x) \theta^{x,t} \theta^{x,t-1} > p^z_{t-1} \theta^{z,t} \theta^{z,t-1}$$

(6.1)

Notice that since $\alpha$ is the same in both sectors (and for both worker types), it does not influence the decision in which sector to search. We define $L^j_t = 2L^j_0$ to be the number of workers that search for a job in sector $j$ at time $t$. Since there is a total of $2L$ workers in the population, at each time $t$ the relation $L^x_t + L^z_t = 2L$ must hold.

When $T^x = 0$ and since $p^x_t = p^z_t$ exactly half of the labor force will be searching for a job in the agricultural sector and the other half in the manufacturing sector. For, the structure of our model is such that both sectors are completely identical except for the presence of the tariff. We observe that the presence of $T^x > 0$ changes the comparative advantage of some workers.

**Observation 6.1** In the presence of a tariff $T^x > 0$, the 'generalists' for which $\theta^{x,t} - \theta^{z,t}$ is negative but small, will search for a job in the agricultural sector although they are more productive in the manufacturing sector.

Notice that this observation does not depend on any form of diminishing returns.\(^6\)

Note as well that the tariff does not only increase the wage directly, but because (as we will see in a moment) it also raises $q^x_t$ it increases the probability of being matched to a job as well. Following Heckman and Honoré (1990) we define the proportion of the population joining the matching process in sector $x$ as,\(^7\)

$$\lambda^x_t = \int_0^{\infty} \int_0^{\infty} f(\theta^x, \theta^z) d\theta^x d\theta^z,$$

(6.2)

where $E\beta^x_t = Er^x_t (1 + T^x) q^x_t = p^x_{t-1} (1 + T^x) q^z_{t-1} = \beta^z_{t-1}$ is the expected ability price in sector $x$ at time $t$ which is equal to the ability price in sector $x$ at time $t - 1$. Thus this parameter is given at time $t$, but can change over time, although with a lag. As a consequence, the proportion of workers in each sector can vary over time. An immediate

\(^6\)Alternatively, instead of modelling heterogeneity in terms of differences in ability in a two-sector economy, one could model heterogeneity as the difference in location in a two-country framework. Then, a tariff levied in one country would give rise to migration of those workers who live closest to the border.

\(^7\)Note that similar expressions hold for sector $z$. 
6.2. The Model in Steady State

The implication of (6.2) is that, if the relative price of ability in sector \( x \) increases at time \( t \), a greater proportion of workers will join the matching process in sector \( x \) at time \( t + 1 \).

The population density of ability in sector \( x \) is:

\[
f^x(\theta^x) = \int_0^\infty f(\theta^x, \theta^z) d\theta^z
\]

(6.3)

The (conditional) density of ability of people who join the matching process in sector \( x \) differs from this population density of ability and is equal to:

\[
g_t(\theta^x | \beta^x > \beta^z) = \frac{1}{\lambda^x} \int_0^{\beta^x} f(\theta^x, \theta^z) d\theta^z,
\]

(6.4)

while in sector \( z \) this density is,

\[
g_t(\theta^z | \beta^z < \beta^x) = \frac{1}{\lambda^z} \int_0^{\beta^z} f(\theta^x, \theta^z) d\theta^z
\]

(6.5)

As individuals pursue their comparative advantage, the observed distribution of ability of the workers searching for a job in each sector differs from the population distribution of abilities. The distortionary effect of the import tariff on the productive potential of the economy follows from multiplying the number of workers who switch sectors as a consequence of the tariff by their productivity difference between both sectors; i.e.,

\[
\int_0^{\infty} \int_0^{\frac{E_{P, l} T^x}{E_{P, l} T^z} \theta^x (1 + T)} f(\theta^x, \theta^z) (\theta^x - \theta^z) d\theta^x d\theta^z
\]

(6.6)

**Observation 6.2** The distortionary effect of the import tariff is given by the number of generalists that work in the protected sector who would have worked in the unprotected sector in the absence of trade protection times the ability difference between the two sectors for each of them.

Given the average ability and proportion of workers who choose to search for a job in sector \( j \), employers now determine the amount of jobs they want to offer. Thus we now turn to the second stage of the matching process, the supply of vacancies. The supply of vacancies by employers depends on the costs of opening a vacancy and on the expected
profit of doing so, which is a function of the fraction of \( stu \) and \( lu \) workers, the average ability of the workers, the number of workers searching, and the price, all evaluated in the sector where the employer is located.

First, we assume that when a firm and a worker do not come to an agreement when they meet, the vacancy disappears, because jobs last for one period only, and the worker becomes or remains unemployed for this period. The payoff from this state is zero for both the employer and the worker. Both firms and workers take part in matching with fixed intensity of search, normalized to unity. The probability that a worker meets a job in some period \( t \) in sector \( j \) is \( q_j^t \). By the assumption of fixed intensities this probability is independent of anything that the worker does. It depends only on the aggregate inputs of firms and workers into matching, which is equal to the number of jobs and the number of workers. Similarly, the probability that a job meets a typical worker is independent of the actions of the firm. It is derived from \( q_j^t \) by making use of the property that jobs and workers meet in pairs. Since jobs meet at most one worker in each round of matching, in equilibrium each vacancy-worker matching will be successful, and so the probability that each worker becomes employed is also equal across worker types: it is independent of the workers’ ability level and irrespective of whether he is \( stu \) or \( lu \).

We are now able to determine the probability, \( pr_{stu}^t \), that a job meets an \( stu \) worker in sector \( j \) at time \( t \). Half of the job seekers in sector \( j \) in period \( t-1 \) die at time \( t \) and they are replaced by \( stu \) workers. Moreover, the number of employed workers in the previous period still alive today are also \( stu \). Since we concentrate in this section on the steady state solution of our model, we determine \( pr_{stu}^t \) on the basis that workers are not moving between the two sectors. Then, as \( L_{j-1}^t = L_j^t \) and, since we look at the model in steady state, \( q_{j-1}^t = q_j^t = q^j \), we have \( pr_{stu}^t = pr_{stu}^{t-1} = pr_{stu}^j \), so that:

\[
pr_{stu}^j = pr_{tu}^j = \frac{1}{2} \frac{L_j^t}{L_j^t} + \frac{1}{2} \frac{L_{j-1}^t q_{j-1}^t}{L_j^t} = \frac{1}{2} \left( 1 + q^j \right). \tag{6.7}
\]

The amount of \( lu \) workers in sector \( j \) is equal to the amount of workers who did not have a job in the previous period and are still alive today. In steady state \( pr_{lu}^t = pr_{lu}^j \), and the probability that a job meets an \( lu \) worker is equal to:

\[
pr_{lu}^j = 1 - pr_{stu}^j = \frac{1}{2} \left( 1 - q^j \right) \tag{6.8}
\]

These probabilities are one determinant of the average quality of job seekers in sector \( j \) and therefore they are also a determinant of the number of jobs offered in each sector. The total number of jobs offered in sector \( j \) at time \( t \) is denoted by \( J_j^t \), while \( e_j^t = q_j^t L_j^t \) is
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defined to be the total employment in sector \( j \) at time \( t \), which is equal to the number of vacancy-worker matching in sector \( j \) at time \( t \). Now we can express the average probability that a vacancy in sector \( j \) is filled, as,

\[
\frac{e_i^j}{J_i^j} = \frac{q_i^j L_i^j}{J_i^j}
\]  

(6.9)

The employer does not know if his vacancy meets an \textit{stu} or an \textit{ltu} worker. Moreover, he is unable to observe the productivity of a potential job seeker. Therefore, in deciding how many vacancies to open, he looks at the expected marginal profit of opening a vacancy. This expected marginal profit is equal to the employer's fraction of the expected value of output which is produced by a particular worker type if the vacancy is filled. Written down in natural logarithms, to take account of the structure of Heckman and Honoré (1990), this yields,

\[
E_i \ln \pi_i^j = \xi_t + \ln p_i^j (1 + T^*) + E_i \ln \theta^j + \ln \frac{q_i^j L_i^j}{J_i^j}.
\]  

(6.10)

where \( T^* = 0 \) and we define

\[
\xi_t \equiv \ln(1 - \alpha) + \ln 2 \left[ p_{t}^{stu,j} + yp_{t}^{ltu,j} \right].
\]

As we have assumed that the employer in sector \( j \) is unable to observe the productivity of a worker he has to form an expectation about it. This expectation, \( E_i \ln \theta^j \), is equal to,

\[
E_i \ln \theta_i^j = E \left( \ln \theta^j \mid \beta_{i-1}^j \theta^j > \beta_{i-1}^j \theta^j \right), \quad j, i = x, z, i \neq j,
\]  

(6.11)

for which an explicit expression is given in Heckman and Honoré (1990).

We assume the cost of opening a vacancy for one period in sector \( j \) to be a constant \( 1/k^j \). In equilibrium the number of vacancies created will be determined by equating marginal benefits of opening a vacancy to marginal costs. Taking account of the fact that we write our model in logs, this results in,

\[
E_i \ln \pi_i^j = -\ln k^j
\]  

(6.12)

We now introduce a specific matching function \( \chi(J_i^j, L_i^j) \) for matching vacancies to workers. This function has the number of vacancies and the number of workers looking for a
job as arguments and it is assumed to be at least twice differentiable, with positive first-order and negative second-order derivatives, homogeneous of degree 1 (constant returns to scale), and it satisfies $\chi(0, L_j^t) = \chi(J_j^t, 0) = 0$.

Total employment in sector $j$ will be equal to this matching function, unless the number of workers or the number of vacancies is smaller. Thus,

$$e_j^t = \min \left[ \chi(J_j^t, L_j^t), J_j^t, L_j^t \right]$$ (6.13)

It is clear from this equation that the only variables that can change the outcome of matching from one period to the next are the endogenous numbers of vacancies and workers. Like Pissarides (1992) we ignore any trivial equilibrium. Non-trivial matching problems arise when $\chi(\ldots)$ is less than both $J_j^t$ and $L_j^t$. Then we have that in equilibrium $E \ln \pi_j^t + \ln k^j = 0$ and using (6.10) we get,

$$\ln J_j^t = \xi_t + \ln p^j_t \left(1 + T^j\right) + E_t \ln \theta^j + \ln \left(q^j_t L_j^t\right) + \ln k^j$$ (6.14)

From this equation we directly observe the following:

**Observation 6.3** The amount of jobs offered in sector $j$ is higher if workers are more likely to find the vacancies ($q^j_t$ higher), when more workers choose to search for a job in sector $j$ ($L_j^t$ higher), when the cost of opening a vacancy in sector $j$ is less ($\ln k^j$ larger), when employers receive a larger fraction of the value of output ($\alpha$ lower), when the value of output is larger ($p^j_t$ and/or $T^j$ larger), when the long-term unemployed are more productive ($y$ larger), when the expected average productivity of workers searching in sector $j$ is larger ($E_t \ln \theta^j$ higher), and when the previous period probability of being matched to an student worker is larger ($p_r^{stu-j}$ larger, $p_r^{stu-j}$ smaller).

This last aspect of the supply of jobs is the source of persistence. The higher the proportion of $ltu$ workers among potential job applicants, the fewer the number of vacancies that come into the market. The market becomes ‘thin’, as there are relatively more job seekers with lower effective productivity. When a shock occurs that raises the number of $ltu$ workers, the probability of unemployment for the new cohort increases. So then the market remains thin, even though the old unemployed have all left unemployment after a maximum of two periods. Thus what we see is that a thin market leads to more job shortage which in turn perpetuates the thinness, as is also the case in Pissarides (1992).

In our model, this persistence in sector $j$ is reinforced by the fact that $L_j^t$ is a positive function of $q_{j-1}^t$. When $q_{j-1}^t$ is lower, $L_j^t$ decreases which results in job destruction in sector $j$, while it results in job creation in sector $i \neq j$. 
6.2. The Model in Steady State

To derive an expression for the matching probability $q^i_t$ we assume a Cobb-Douglas matching technology, 8

$$\chi(J^i_t, L^i_t) = \left[a J^i_t\right]^b [L^i_t]^b,$$  

(6.15)

where $0 < b < 1$. In this equation $a > 0$ is a scaling constant measuring the efficiency of the matching technology. Following our earlier assumption that $\chi(.,.)$ is less than both $J^i_t$ and $L^i_t$, we have that $e^i_t = q^i_t L^j_t = \chi(J^i_t, L^j_t)$. Using this relationship and (6.15), we have,

$$q^i_t = \frac{[a J^i_t]^b [L^j_t]^b}{L^i_t}$$  

(6.16)

Assuming that $b = \frac{1}{2}$, i.e. that firms and workers are equally effective in finding partners, and expressing (6.16) in logs we have,

$$\ln q^i_t = \frac{1}{2} \ln a + \frac{1}{2} \ln J^i_t - \frac{1}{2} \ln L^j_t$$  

(6.17)

Substituting $J^i_t$ from (6.14) and rewriting results in,

$$\ln q^i_t = \ln a + \ln p^i_t (1 + T^j) + \xi_t + \mathbf{E}_t \ln \theta^j + \ln k^j$$  

(6.18)

This is a difference equation in $q^i_t$, since $\mathbf{E}_t \ln \theta^j$ and both $p^x_{t,ta,j}$ and $p^z_{t,ta,j}$ depend on $q^i_{t-1}$. In the stationary (steady state) equilibrium we have $q^i_t = q^i_{t-1} = q^i$ and we know that workers do not move between the two sectors, $\lambda^i_t = \lambda^i_{t-1} = \lambda^i$. Thus, we can solve for $q^i$, which we do implicitly. We choose the parameters $a,k^j,\alpha,y,T$ and $p^j$ in such a way that $\ln q^i_t \leq 0$ so that $0 \leq q^i_t \leq 1$. Notice, from expression (6.18) that the tariff raises the matching probability in the agricultural sector which, referring to equation (6.1), implies our answer to question (a) in the Introduction to this chapter:

**Conclusion 6.1** Import protection distorts the comparative advantage of workers as it raises both the wage as well as the probability of finding a job in the protected sector in relation to the unprotected sector. Even without diminishing returns, tariffs reduce the productive capacity of the economy.

---

8Pissarides (1992) showed that, for general matching technologies, there is a possibility for multiple equilibria. This general case could offer an explanation for the different experiences faced by different countries.
Using the following equation for aggregate employment,

\[ \ln E_t = \ln \epsilon^*_t + \ln e^*_t = \ln (q^*_t L^*_t) + \ln (q^*_t L^*_t), \]  

(6.19)

we have,

\[ \ln e^*_t = \ln a + \xi_t + \ln p^*_t (1 + T^j) + E \ln \theta^j + \ln k^j + \ln L^*_t \]  

(6.20)

Notice the difference between equations (6.18) and (6.20):

**Observation 6.4** The expression for the matching probability in sector \( j \) is independent of the number of workers searching in that sector, and thus depends only on the 'quality' of the workers searching for a job in that sector. Employment in each sector also depends on the number of workers searching in that sector, and thus exhibits both quality and quantity effects.

We now have a model which exhibits imperfect information, worker heterogeneity, and a source of persistence. With this model we analyze the consequences of trade reform for employment in the agricultural sector and in the manufacturing sector. Moreover, we are able to consider the effects of trade reform on the distribution of wages.

### 6.3 Trade Liberalization and Employment

Abolishing the tariff \( T^x \) in the agricultural sector affects employment in both sectors through various channels. Since workers lose part of their skills during unemployment, aggregate employment may be negatively affected in a persistent way. Before we are able to derive analytical expressions for these effects on employment in both sectors, we first have to specify the fractions of \( stu \) and \( ltu \) workers in both sectors, when the system is not in steady state. Out of steady state, expressions (6.7) and (6.8) change since we have to account for (costless) labor mobility.

Suppose \( T^x \) is abolished (i.e. set to 0) at time \( t \). At time \( t + 1 \) people move out of sector \( x \) and into sector \( z \) after the resulting decrease in \( p^*_t \), so that,

\[ p^*_{stu,x,t+1} = \frac{1}{2} \left( 1 + q^*_t \right), \]

(6.21)

\[ p^*_{stu,z,t+1} = \frac{1}{2} \frac{L^*_t + L^*_t q^*_t}{L^*_t} + \frac{L^*_t + L^*_t - L^*_t}{L^*_t} p^*_{stu,z,t+1}. \]

(6.22)
6.3. Trade Liberalization and Employment

Given our assumptions, the number of workers that move to the other sector is proportionally divided over the different types of workers. Hence, a proportion \( pr_{t+1}^{stu,x} (pr_{t+1}^{ltu,z}) \) of the workers moving from sector \( x \) to \( z \) consists of \( stu \) (\( ltu \)) workers. Consequently, the proportion of workers of a certain type in sector \( x \) does not change as a consequence of workers moving out of this sector.\(^9\) This explains (6.21).

In sector \( z \), \( L_t^z q_t^z \) workers were \( stu \) in the previous period. Of these workers, \( \frac{1}{2} L_t^z q_t^z \) are still alive at \( t+1 \). Also, half of the workers employed in sector \( z \) at time \( t \) die between \( t \) and \( t + 1 \) and are replaced by new entrants which are \( stu \). Hence the factor \( \frac{1}{2} (L_t^z + L_t^z q_t^z) \) of (6.22). The second term shows the number of workers moving out of sector \( x \), flowing into sector \( z \), times the probability that these workers were matched to a job in the previous period.

Using these two expressions we now derive the analytical expressions for the consequences of the permanent abolition of the import tariff that was levied on the agricultural product, for sector \( x \) (in Section 6.3.1) respectively sector \( z \) (in Section 6.3.2), thereby answering question (b) in the Introduction to this chapter.

### 6.3.1 The Effects of Trade Liberalization in Sector \( x \)

Using equations (6.21) and (6.22) and the framework developed in the previous section we are now able to analytically characterize the effects of trade liberalization for the sector that was initially protected.\(^10\) The effects of such a shock follow from considering a decrease in \( p_t^z \). Almost all of its effects can be illustrated by looking at the effects of this shock on \( q_t^z \) and \( q_{t+1}^z \) respectively on \( q_t^z \) and \( q_{t+1}^z \). The change in \( p_t^z \) at time \( t \) due to the reform, affects employment in sector \( x \) at \( t \), but not yet in sector \( z \) at \( t \). Sector \( z \) is affected as soon as workers start to move. Labor moves with a lag and, therefore, sector \( z \) will not be affected until time \( t + 1 \). Thus,\(^11\)

\[
\frac{\partial \ln q_t^z}{\partial p_t^z} = \frac{\partial \ln q_t^z}{\partial p_t^z} =
\]

\[
\frac{\partial \ln p_t^z + \partial E_t \ln \theta^z}{\partial p_t^z} + \frac{\partial \ln (pr_{t}^{stu,x} + ypr_{t}^{ltu,x})}{\partial p_t^z} = \frac{1}{p_t^z}
\]

\(\text{(6.23)}\)

\(^9\)Note that \( pr_{t+1}^{stu,z} \neq pr_{t+1}^{ltu,x} \), since \( \frac{\partial q_t^z}{\partial p_t^z} \neq 0 \) and thus also \( \frac{\partial pr_{t+1}^{stu,x}}{\partial p_t^z} \neq 0 \), as is derived below.

\(^10\)In the next section we provide illustrative simulations of this analytical solution and discuss the sensitivity of these effects to variation in parameter values.

\(^11\)See the Appendix for details on the derivation.
From equation (6.23) it is easy to see that employment in sector $x$ at time $t$ depends positively on the change in the price level. Therefore.

**Conclusion 6.2** The only effect of trade liberalization at time $t$ on employment in sector $x$ comes via its direct impact on the expected profitability of opening vacancies. The composition of workers searching for a job in sector $x$ is not affected at time $t$ and employment in the formerly protected sector decreases.

At time $t+1$ some workers, exploiting their comparative advantage, move out of sector $x$ and instead search for a job in sector $z$. The workers that move out of the agricultural sector are the generalists; i.e. those workers for which the difference in ability between the two sectors is small. Workers will move because the abolishment of the tariff decreases the wage directly and because $q_x^e$ has decreased, while $q_z^e$ has not changed. In other words, the wage and employment prospects in the agricultural sector have decreased and the workers that move are the ones that moved into the agricultural sector in response to the trade protection in the first place.

The effects on the matching probability in $x$ at $t + 1$ depends on a number of factors. First of all, employment has decreased in sector $x$ at time $t$ which has increased the number of $ltu$ workers at $t + 1$ in the population and therefore the number of $ltu$ workers searching for a job in that sector. However, at the same time the workers that move out may not have been the most productive in $x$, thereby increasing the average skill level of the workers who keep on searching for a job in $x$. The effect of the abolishment of the import tariff at $t$ on the matching probability in $x$ at $t + 1$ depends on whether the overall impact of these effects is positive or negative. In the Appendix we show that,

$$
\frac{\partial \ln q_{x,t+1}}{\partial p_{x}^{t}} = -\frac{\sigma_{xx} - \sigma_{xz}}{\sigma^2} h'(-c_{*,t+1}^x) \frac{2}{p_{x}^{t}} + \frac{\partial \ln \left( pr_{t+1}^{ltu,x} + y r_{t+1}^{ltu,x} \right)}{\partial p_{x}^{t}} - \frac{\sigma_{xz}}{\sigma^2} h'(-c_{*,t+1}^x) \frac{2}{p_{z}^{t}} + \frac{1}{1 + y + (1 - y) q_{x}^e} \frac{1}{p_{x}^{t}},
$$

with $h(.)$ and $c_{*,t+1}^x$ as given in the Appendix.

The first term on the rhs of (6.24) denotes the effect of the price change on mean ability in sector $x$. Since workers move out of sector $x$ and into sector $z$, the composition of workers searching for a job in $x$ has changed. We assume that $\sigma_{xx} > \sigma_{xz}$, where $\sigma_{xz}$ can be equal to zero, negative or positive. For example, $\sigma_{xz} < 0$ indicates specialization: a high ability level implies that the worker has specialized on producing in one sector and then the probability is large that this worker is not very productive in the other sector.
Vice versa, \( \sigma_{zz} > 0 \) indicates that a worker with high ability in one sector tends to have higher ability in the other sector as well.

The workers that move from sector \( x \) to sector \( z \) are those whose difference in ability between the two sectors is the smallest, since for these workers the liberalization may shift their comparative advantage from sector \( x \) to sector \( z \). Among other things, this effect is captured by \( h'(c_{x,t+1}^z) \), which is positive. As a consequence, the first term on the rhs of (6.24) is negative and the movement of workers out of sector \( x \) and into sector \( z \) has a positive effect on mean ability in sector \( x \), because of the negative shock to \( p_x^t \). The reason is straightforward. After the liberalization, only the most able ('specialists') workers stick with agricultural production. Thus the direct impact at time \( t \) of the shock to the matching probability between jobs and workers in sector \( x \), is mitigated by labor moving out of this sector at \( t + 1 \).

However, there is a second effect of the shock on the quality of workers searching for a job in \( x \). This effect is captured by the second term on the rhs of (6.24) and it shows how the shock affects the effectiveness of workers in converting their ability into output. The decrease in \( q_x^t \) decreases the number of \( stu \) workers in \( x \) and increases the number of \( ltu \) workers. The movement of workers has no further effect on the fraction of \( stu \) and \( ltu \) in sector \( x \). This second term on the rhs of (6.24) is positive which implies that the negative shock to the price level at \( t \) decreases the fraction of \( stu \) at \( t + 1 \) which in turn decreases the matching probability at \( t + 1 \) in sector \( x \). This decrease in the quality of workers searching for a job in sector \( x \) combined with the increase due to the effect that average ability of the job seekers has increased determines the 'quality' effect of the shock in sector \( x \).

Recall from our previous discussion that we can separate the effect of a sector-specific shock on the log of sectoral employment into this 'quality' effect and a 'quantity' effect,

\[
\frac{\partial \ln e_{x,t+1}^t}{\partial p_x^t} = \frac{\partial \ln q_{x,t+1}^x}{\partial p_x^t} + \frac{\partial \ln L_{x,t+1}^x}{\partial p_x^t},
\]

(6.25)

where the first term on the rhs of (6.25) refers to the 'quality' effect and the second term on the rhs refers to the 'quantity' effect of a sector-specific shock on sectoral employment. This quantity effect is negative as workers move out of sector \( x \). Depending on the effect of the shock on the matching probability, employment may either increase or decrease in sector \( x \) from \( t \) to \( t + 1 \). In Section 6.4, numerical examples show that in general employment in the protected sector will decrease as a result of the shock, but for the time being we have the following:

**Conclusion 6.3** The response of employment in sector \( x \) at time \( t + 1 \) due to trade
liberalization is uncertain. On the one hand employment increases because the fraction of job seekers in this sector that are ‘specialists’ becomes higher, while on the other hand employment decreases because of higher previous period unemployment and due to the lower number of job applicants.

6.3.2 The Effects of Trade Liberalization in Sector $z$

The effect of trade reform on employment in sector $z$ at $t$ is given by,

$$\frac{\partial \ln q^z_t}{\partial p^z_t} = \frac{\partial \ln L^z_t}{\partial p^z_{t+1}} = \frac{\partial \ln e^z_t}{\partial p^z_t} = 0$$  \hspace{1cm} (6.26)

The shock to $p^z_t$ has no effect on either the composition of job seekers in $z$ nor on the amount of workers searching for a job in the manufacturing sector.

**Conclusion 6.4** Employment in the unprotected sector at time $t$ is unaffected by trade reform at time $t$.

In the Appendix we show that.

$$\frac{\partial \ln q^z_{t+1}}{\partial p^z_t} = \frac{\sigma_{zz} - \sigma_{zx} h'(c^z_{x,t+1})}{\sigma^2} \cdot \frac{2}{p^z_t} + \frac{\partial \ln (p^{stu}_{t+1} + yp^{ltu}_{t+1})}{\partial p^z_t}.$$  \hspace{1cm} (6.27)

with $h(.)$ and $c^z_{x,t+1}$, as well as an explicit expression for the second term on the rhs, as given in the Appendix. Equation (6.27) shows that the quality effect in sector $z$ is also determined by both the change in the distribution of skills after workers have moved to this sector and by the effect of this movement of labor on the fractions of $stu$ respectively $ltu$ workers in $z$ at $t + 1$.

By similar reasoning as above, we can establish that the first term on the rhs is positive. Therefore, this effect causes the decrease in $p^z_t$ to decrease average ability of the workers searching for a job in $z$. The intuition behind this result is that only the workers for whom the difference in ability between the two sectors is small are moving. As a result, the workers that enter sector $z$ are the least specialized workers. Since employers cannot observe the ability of job seekers, the average ability level of the workers searching for a job in $z$ has decreased which in turn decreases the matching probability at $t + 1$.

The second term refers to the fact that after trade has been reformed, the fraction of $stu$ workers in $x$ decreases while the fraction of $ltu$ workers increases. Since workers move from $x$ to $z$, the quality of workers searching for a job in the manufacturing sector...
is affected through this channel as well. If the fraction of $ltu$ workers was higher is $x$ than in $z$, the movement of workers together with imperfect information by employers implies that the quality of job seekers in $z$ is negatively affected.

**Conclusion 6.5** The response of employment in sector $z$ at time $t + 1$ due to trade liberalization is uncertain. On the one hand employment decreases because the fraction of job seekers in this sector that are 'generalists' becomes higher, while on the other hand employment increases due to the high number of job applicants. Furthermore, in case the fraction of long-term unemployed workers had been higher (lower) in the protected sector in the previous period, the quality of the pool of job applicants in the unprotected sector deteriorates (improves) due to the inflow of workers from the formerly protected sector.

Finally, we briefly consider what happens to aggregate employment at $t + 1$,

$$
\frac{\partial \ln E_{t+1}}{\partial p_t^z} = \frac{\partial \ln e_{t+1}^x}{\partial p_t^x} + \frac{\partial \ln e_{t+1}^z}{\partial p_t^z} = \frac{\partial \ln q_{t+1}^x}{\partial p_t^x} + \frac{\partial \ln q_{t+1}^z}{\partial p_t^z},
$$

(6.28)

as in the aggregate the quantity effects of shocks cancel out. The effect of the shock on aggregate employment at $t + 1$ depends on the relative impact of the shock on the quality of job seekers in the sectors $x$ and $z$. Aggregate employment can either increase or decrease and it will be interesting to consider what has happened to aggregate (un)employment after the economy has settled in its new steady state. We take this issue up in our numerical illustrations in the next section.

Finally, it is very difficult to discuss in general the effects of trade reform for the distribution of wages. What we can say is that by moving to the manufacturing sector, the generalists limit the negative effect of trade liberalization on their expected wage, although their expected wage still decreases. The agricultural specialists see their expected earnings decrease by more because of the direct impact of trade liberalization on the level of wages, but also because employment opportunities have decreased. The workers in manufacturing earn the same wage if matched to a job, although their expected wage declines as well because of increased competition for jobs which decreases the probability of employment. This effect arises because the workers in manufacturing cannot be distinguished from the agricultural workers that moved into the unprotected sector. Thus, concerning question (c), we have:

**Conclusion 6.6** Trade liberalization affects wages negatively. Which workers stand to lose most from trade reform does not depend on the distinction between (low and high
skilled) individuals, but on the different productivity levels of a single individual with respect to the different sectors of an economy. Specialized workers in the protected sector are most affected, then the generalists that switch to the other sector in response to trade liberalization, and the decline in expected wages is smallest for manufacturing workers.

Thus, one cannot say in general that trade reform implies increased income inequality, nor can one say that unemployment effects will be concentrated among the least-skilled workers. The reason for this result is that firms cannot observe worker quality before hiring, jobs last for one period only, and the quality of the overall (combining both sectors) unemployment pool is invariant to the trade policy except for the fraction of long-term unemployed workers. The model therefore does not predict that lower skilled workers will be worse off or more likely to be unemployed compared to higher skilled workers when international trade is liberalized.

6.4 Some Illustrative Simulations

On top of our analytical solution to the model, it is instructive to give some numerical illustrations of the dynamics of the model after a shock has occurred. In this section we will analyze the effects of trade reform in the form of abolishing an import tariff completely at time $t = 1$. We focus on the amount of job seekers and unemployment in each sector as well as the effects on aggregate unemployment. We discuss how sensitive our conclusions are to variations in the parameters of interest, such as the degree of loss of skills and the variance of the distribution of ability.

In our base scenario we assume the following parameter values: $T^x = 0.1$, $y = 0.90$, $k^x = k^z = 0.6$, $\mu_x = \mu_z = 1$, $\sigma_{xz} = \sigma_{zz} = 1$, and $\sigma_{xz} = 0$. We posit $L = 1000$ so that in total there are 2000 workers of which, on the basis of comparative advantage, 1077 search for a job in the agricultural sector and 923 search for a job in the manufacturing sector. The 10% tariff results in a situation in which 77 workers see their comparative advantage change such that they search for a job in the agricultural sector, although they are more able in the manufacturing sector. In this case, the following steady state values are obtained: $q^z = 0.8991$, $q^i = 0.8626$, $e^z = 968.43$, $e^z = 796.12$, and $E = 1764.55$. After the tariff of 10% is abolished, $p^z_1 = p^z_1 = 1$. The dynamics towards a new steady state after the abolition of the tariff are presented in Table 6.1. In the table, $U_j$ for $j = x, z$, denotes the percentage unemployment in sector $j$ and $U_t$ indicates the aggregate percentage of unemployment.

As one can see from Table 6.1, the direct impact of trade liberalization at time $t = 1$ is to decrease the matching probability in sector $x$ and, as a consequence, to increase the
6.4. Some Illustrative Simulations

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<th>( q^z_t )</th>
<th>( L^x_t )</th>
<th>( U^x_t )</th>
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Table 6.1: The effects of trade liberalization with a tariff of 10 percent.

aggregate unemployment rate in this sector to 18.26%. Labor moves with a lag and as a consequence sector \( z \) is unaffected at \( t = 1 \). So aggregate unemployment increases only because of the direct negative impact of the shock on employment in sector \( x \). At \( t = 2 \) labor starts to move. The decrease in \( q^x_t \) has increased the fraction of \( ltu \) in sector \( x \) and has therefore decreased average skill in sector \( x \). Nevertheless, we see that \( q^z_t \) has increased compared to the previous period. We conclude that average ability of the workers that remain in \( x \) must have increased considerably. Many workers move and, as we discussed in the previous section, this affects the quality of the workers searching for a job in \( z \) (and therefore \( q^z_t \)) through two channels. First of all, the decrease in \( q^x_t \) decreases the fraction of \( stu \) workers in \( z \) at time 2. Second, average ability in \( z \) decreases. Both effects depress the average quality of job seekers in the manufacturing sector and the unemployment rate in this sector increases to a maximum of 17.037% at \( t = 2 \). The effects on unemployment in sector \( x \) and \( z \) of labor movement almost cancel out since the aggregate unemployment rate is more or less stable after period 1. Thus, this simulation seems to suggest that the persistent increase in the aggregate unemployment rate almost entirely depends on the direct impact of trade reform. Labor movement between sectors does, however, affect sectoral (un)employment. In this illustration we see overshooting before the economy finally settles in its new steady state at \( t = 11 \).

Suppose that a larger tariff, \( T = 20\% \), had been in place. The results of trade reform in this case are presented in Table 6.2. The results are qualitatively the same as for \( T = 10\% \) although all the effects are approximately twice as large.

We proceed by looking at an illustration in which the degree of loss of skills is larger. More specifically, we posit \( y = 0.8 \); i.e. long-term unemployed workers are less capable
Table 6.2: The effects of trade liberalization with a tariff of 20 percent.

Of transforming their ability into productivity. The results are summarized in Table 6.3. With $y = 0.8$, unemployment is larger in both sectors in the initial, protected, steady state. Note that the aggregate unemployment rate increases slightly more after trade has been reformed compared to the case in which $y = 0.9$.

Up to now, we have assumed that both sectors are identical before any shocks hit the economy. We will now analyze how our results change when we introduce differences between sectors, for example because $\sigma_{xx} = 1$ while $\sigma_{zz} = 2$ for $k^x = k^z = 0.55$.

In the initial steady state the unemployment rate is now very high in the agriculture and much smaller in the manufacturing sector. This is because some workers now have a very high ability in $z$ compared to their ability in $x$ and, as a consequence, more workers are searching for a job in $z$ than in $x$ compared to the situation in which both sectors were identical. After trade has been reformed, less workers move compared to the case in which both sectors became identical after the liberalization, since workers in agriculture are more specialized. The aggregate unemployment rate increases by less percentage points after trade has been reformed, although the rise in unemployment in the manufacturing sector becomes larger compared to our baseline scenario in Table 6.1. The reason for this is that the workers who were searching for a job in $x$ before the shock are relatively unable workers in $z$. Then, after the shock, only a small amount of workers move, but this movement of workers reduces the average quality of job seekers in $z$ a lot precisely because they have low ability in $z$. Moreover, as one can see from equation (A6.26) in the Appendix, because $q^x$ is smaller than $q^z$, the fraction of $stu$ workers in $z$ decreases if workers move in from $x$ after the tariff has been abolished.

Next, suppose that $\sigma_{xx} = 2$ and $\sigma_{zz} = 1$ for $k^x = k^z = 0.55$. The dynamics for

<table>
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6.4. Some Illustrative Simulations

Table 6.3: The effects of trade liberalization with a tariff of 10 percent and larger loss of skills ($y=0.8$).

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<th>$L^*_t$</th>
<th>$U^*_t$</th>
<th>$L^*_t$</th>
<th>$U^*_t$</th>
<th>$U_t$</th>
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<td>1000.00</td>
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Table 6.4: The effects of trade liberalization with a tariff of 10 percent, $\sigma_{xx} = 1$, and $\sigma_{zz} = 2$. 

<table>
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<th>$q^*_t$</th>
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<th>$U^*_t$</th>
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<th>$U^*_t$</th>
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<td>926.35</td>
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</table>
Chapter 6. Trade Liberalization and Labor Market Dynamics

Table 6.5: The effects of trade liberalization with a tariff of 10 percent, $\sigma_{xx} = 2$, and $\sigma_{zz} = 1$.

<table>
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<td>926.34</td>
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</table>

this simulation can be found in Table 6.5. Compared to the case presented in Table 6.4, unemployment in sector $x$ increases by more and unemployment in $z$ by less percentage points. Labor mobility and the change in the aggregate unemployment rate are approximately the same as for $\sigma_{xx} = 1$ and $\sigma_{zz} = 2$. The employment rate in $z$ is much less adversely affected after the liberalization since, under the latter parameter configuration, the workers that move in general do not have very low ability. Moreover, because $q^z$ is much larger than $q^x$ before the shock, the fraction of $stu$ worker in $z$ may actually increase after the shock.

These simulations give some insight into the interactions between the quantity and quality effects that arise after trade has been reformed. Labor movement together with imperfect information implies that spillovers between sectors arise when one sector faces increased competition. If workers move with a lag and lose part of their skills during unemployment, aggregate unemployment is permanently higher after an import tariff has been abolished, unless other measures are included in the liberalization package that prevent unemployment from rising. We discuss such extensions of the reform package in the next section.

6.5 Expanding the Liberalization Package

A tariff levied on the agricultural product distorts both the goods market and the labor market. As we saw above, the latter distortion comes from the fact that a tariff affects the comparative advantage of some workers. Although we did not take the distortion on the
consumption side of the market caused by the tariff into account, it is well known that a production subsidy is often a better instrument than a tariff because it targets directly the particular activity one wants to encourage. One of these activities could be the protection of domestic jobs in which case the subsidy should be directed to wage-costs. As we saw above, abolishing an import tariff increases unemployment permanently. In this section we are concerned with question (d) as stated in the Introduction to this chapter. Thus, we study what features should be added to the liberalization package to prevent any undesirable side-effects of trade liberalization. In particular, we analyze how to alleviate the distortion on the production and consumption side of the market simultaneously by replacing the import tariff by a wage-cost subsidy, such that any unemployment effects of trade liberalization are mitigated.\footnote{Botman (1999) discusses the effectiveness of vouchers as a way to finance unemployment benefits for reducing unemployment.}

First of all, we study the effectiveness of the standard policy prescription: replace the import tariff by giving a wage-cost subsidy to the protected sector. One can see from equation (6.18) that replacing the tariff, \( T^x \), by a subsidy, \( s^x \), which decreases the costs of opening a vacancy to \( \frac{1}{k(1 + s^x)} \) such that \( T^x = s^x \) with \( s^x = 0 \) results in,

\[
\ln q^i_t = \ln a + \xi_i + \ln p^i_t + E_i \ln \theta^j + \ln k^j (1 + s^j) \tag{6.29}
\]

As a consequence, the matching probability in both sectors will remain the same when a wage-cost subsidy of 10% is given to the agricultural sector instead of levying an import tariff equal to 10%. The same amount of workers search in each sector as was the case with the tariff in place and employment in each sector remains the same. Thus, the steady-state outcome will not be affected by trade reform. This way we get rid of the consumption side distortion although the labor market distortion is still present. For, with the tariff in place we saw that the comparative advantage of workers changes in such a way that from an ability point of view too many people work in the agricultural sector since wages are artificially high in this sector. Thus, the total productive capacity of the economy is still not at full potential.

**Observation 6.5** Replacing an import tariff by giving a wage-cost subsidy with the same size to the protected sector may eliminate the distortion on the consumption side of the market, but not the one on the labor market as still not all workers specialize on the basis of their comparative advantage.

However, one can overcome the latter labor market distortion as well. The way to do this is by giving a lump-sum financed wage-cost subsidy to both sectors such that workers...
work in the sector where they are most able and such that aggregate unemployment will not increase. Moreover, such a general subsidy will be less expensive than giving a subsidy to the agricultural sector alone.

To give an indication of the size of such a general subsidy, consider the simulation result (for $k^x = k^z = 0.6, T^y = 10\%, y = 0.9, \sigma_{xx} = \sigma_{zz} = 1$), presented in Table 6.6. Subsidizing both sectors, financed by lump-sum taxation, protects long-term employment to the same degree as levying an import tariff on one sector and does not distort product and labor markets. Moreover, subsidizing both sectors is cheaper than subsidizing only the agricultural sector. For in the latter case one gives a 10% subsidy to 968.43 jobs ($q_t^x \times L_t^x$) while in the former case, a 5% subsidy is given to 968.43 jobs in $x$ respectively a 5% subsidy for 796.12 jobs in the manufacturing sector. The reason for this cost advantage of a general subsidy is that if you only subsidize employment in the previously protected sector, you are giving subsidies to too many workers. So the fact that a sector-specific subsidy does not eliminate the labor market distortion is also the cause for why such a specific subsidy is more costly than a general wage-cost subsidy. On the other hand, a general subsidy results in transitional dynamics in which aggregate unemployment temporarily rises. Thus.

**Table 6.6: Replacing the tariff by a wage-cost subsidy in both sectors.**

<table>
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<th>$q_t^z$</th>
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</table>

**Conclusion 6.7** Adding a general wage-cost subsidy to the liberalization package protects employment better, and at lower cost, than including a subsidy to the agricultural sector only, although unemployment temporarily rises.
6.6 Concluding Remarks

In this chapter we have discussed an equilibrium-search model with worker heterogeneity, imperfect information, and loss of skills during unemployment. The heterogeneity of workers yields an important mechanism through which an import tariff distorts the labor market. For, such a tariff changes the comparative advantage of some of the least-specialized workers. The wage and the employment prospects for these generalists become larger in the protected agricultural sector, although they are more able in the manufacturing sector. Limiting free trade may not only reduce specialization on the basis of comparative advantage of countries, but also of workers.

Because a tariff distorts both the consumption side of the market and the labor market, trade liberalization sounds like a plausible thing to do. However, although not all labor is sector-specific it is not completely mobile as well. If labor moves with a lag, employers face imperfect information concerning the ability of job seekers, and workers lose part of their skills during unemployment, trade liberalization increases the aggregate unemployment rate persistently through important sectoral interactions.

Moreover we have argued that there are distributional implications associated with trade reform. Trade liberalization affects relative output and factor prices between sectors and therefore labor allocation. As a consequence, its impact on the wage distribution depends critically on the ability of individuals in different sectors as this determines to what extent they can adjust to such relative price changes. Thus, which workers stand to lose most from trade reform does not depend on the distinction between (low and high skilled) individuals, but on the different productivity levels of a single individual with respect to the different sectors of an economy. The most specialized workers in the agricultural sector have most to lose, the generalists mitigate their loss by switching sectors, but still they lose. Finally, manufacturing workers experience fiercer competition for jobs than was the case when trade was still protected. Our simulations indicate that the unemployment rate in the manufacturing sector increased considerably after the liberalization of trade so that this may be an important aspect of trade reform as well.

Although a tariff may protect domestic employment, a wage-cost subsidy is generally more efficient on the grounds that it does not distort the consumption side. We have shown that simply replacing the tariff by a wage-cost subsidy to the agricultural sector has the disadvantage that it does not alleviate the labor market distortion. Because this distortion remains present it is also a relatively costly way to protect domestic employment since too many jobs will be subsidized. We argue that it is better to give a wage-cost subsidy to both sectors since then the comparative advantage of workers will no longer
be distorted, which will also make such a general subsidy cheaper compared to a sector-specific subsidy. The picture that emerges from our chapter then is that if one wants to liberalize trade and prevent the distortion of comparative advantage of workers, the cheapest way to do so is to replace the import tariff by a general wage-cost subsidy which will prevent unemployment from rising permanently.

Although we apply our model to the specific setting of trade reform, it is more general and can be used to analyze other forms of sector-specific shocks affecting relative prices as well. From this point of view, two final observations are relevant. First of all, including sector-specific learning-by-doing may result in a higher level of employment to start with, but larger unemployment in the long-run, after shocks have hit the economy, as workers become less mobile between sectors. Less mobility between sectors is then the result of workers waiting for the shock to pass as they do not want to run the risk of losing that part of their skills that they accumulated in the previous period. Stimulating people to become ‘generalists’ instead of ‘specialists’ may then be an interesting long-run option, although it comes at a short run cost.

Second, the fact that specialization may turn out to be disadvantageous in the long-run in our model when a country is exposed to a lot of shocks has an immediate application to the distinction between specialization on the basis of absolute versus comparative advantage. The number of goods for which an economy has an absolute advantage is at least as large as the number for which it has a comparative advantage. Employment will probably be larger in the short-run if the economy specializes on the basis of comparative advantage. However, if the economy is hit by repeated shocks, unemployment may be lower in the long-run if the economy had a more diversified production package on the basis of absolute advantage. Countries specializing in the production of one good in the presence of persistent unemployment, sector-specific shocks, and lagged labor mobility, may be less well-off in the long run as workers have no where to go if a shock hits the economy unless workers are mobile internationally.

### 6.7 Appendix

To be able to study the effects of trade reform on both sectors of our model, we derive the influence of a shock to \( p^* \) on \( q^j_{t+s+1} \), for \( j = x, z, s = 0, 1, 2, \ldots \) in this Appendix. These effects are illustrated by looking at the effect of a negative shock, coming from trade liberalization, in \( p^* \) on \( q^j_t, q^j_{t+1}, q^j_t \) and \( q^j_{t+1} \). The effects at times \( t + s, s \geq 2 \) do not add much insight and are therefore neglected. They can be deduced in a similar fashion. The analytical derivations of the formulae for the partial derivatives are in two separate
subsections.

6.7.1 Derivative of $q_t^x$ and $q_{t+1}^x$ with respect to $p_t^x$.

In this subsection we determine $\frac{\partial \ln q_t^x}{\partial p_t^x}$ and $\frac{\partial \ln q_{t+1}^x}{\partial p_t^x}$. First,

$$\frac{\partial \ln q_t^x}{\partial p_t^x} = \frac{\partial \ln p_t^x}{\partial p_t^x} + \frac{\partial E_t \ln \theta^x}{\partial p_t^x} + \frac{\partial \ln \left( pr_{t+1}^{xu,x} + yp_{t+1}^{lu,x} \right)}{\partial p_t^x} = \frac{\partial \ln p_t^x}{\partial p_t^x} = \frac{1}{p_t^x},$$

since a change in $p_t^x$ does not affect the expected skill level in sector $x$ at time $t$ or the probability of meeting a worker of either type at time $t$.

Second,

$$\frac{\partial \ln q_{t+1}^x}{\partial p_t^x} = \frac{\partial \ln p_{t+1}^x}{\partial p_t^x} + \frac{\partial E_{t+1} \ln \theta^x}{\partial \ln \beta_{t+1}^x} + \frac{\partial \ln \left( pr_{t+1}^{xu,x} + yp_{t+1}^{lu,x} \right)}{\partial p_t^x} =$$

$$= \frac{\partial E_{t+1} \ln \theta^x}{\partial \ln \beta_{t+1}^x} + \frac{\partial \ln \left( pr_{t+1}^{xu,x} + yp_{t+1}^{lu,x} \right)}{\partial p_t^x},$$

as we consider the case of a permanent sector-specific shock and $\ln E_{t+1} \beta_{t+1}^x = \ln \beta_{t}^x$.

Heckman and Honoré (1990), show that:

$$\frac{\partial \ln E_{t+1} \beta_{t+1}^x}{\partial \ln \beta_{t+1}^x} = \frac{\partial E_{t+1} \left( \ln \theta^x \ln P_x > \ln P_z \right)}{\partial \ln \beta_{t+1}^x} = -\frac{\sigma_{xz} - \sigma_{xz}h'(-c_{t+1}^x)}{\sigma^2}$$

with,

$$c_{t+1}^x = \ln \frac{E_{t+1} \beta_{t+1}^x}{E_{t+1} \beta_{t+1}^x} + \mu_x - \mu_z,$$

$$c_{t+1}^x = \frac{c_{t+1}^x}{\sigma},$$

$$h(-c_x) = \int_{-c_x}^{0} \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}c^2}$$

and where $h'(.)$ indicates the first derivative of $h(.)$ with respect to $\ln E_{t+1} \beta_{t+1}^x$. Furthermore,

$$\frac{\partial \ln \beta_{t+1}^x}{\partial p_t^x} = \frac{\partial \ln \left( q_t^x p_t^x \right)}{\partial p_t^x} = \frac{\partial \ln q_t^x}{\partial p_t^x} + \frac{\partial \ln p_t^x}{\partial p_t^x} =$$

$$= \frac{1}{p_t^x} + \frac{1}{p_t^x} = \frac{2}{p_t^x},$$

(A6.3)
and thus,
\[
\frac{\partial \ln q^t_{t+1}}{\partial p^t} = -\frac{\sigma_{xx} - \sigma_{xx}h'(\tau_{*,t+1})}{\sigma^2} \frac{2}{p^t} + \frac{\partial \ln \left( \frac{1}{p^t} \right)}{\partial p^t} + \frac{\partial \ln \left( \frac{1}{p^t} \right)}{\partial p^t} + \frac{\partial \ln \left( \frac{1}{p^t} \right)}{\partial p^t} \frac{1 - y}{p^t}.
\]

Now, we determine the final term in this expression. Substituting \( p^t_{t+1} \) gives
\[
\frac{\partial p^t_{t+1}}{\partial p^t} = \frac{\partial \left( 1 - p^t_{t+1} \right)}{\partial p^t} = -\frac{\partial p^t_{t+1}}{\partial p^t}.
\]

and thus
\[
\frac{\partial \ln \left( \frac{1}{p^t} \right)}{\partial p^t} = \frac{\partial \ln \left( \frac{1}{p^t} \right)}{\partial p^t} = \frac{\partial \ln \left( \frac{1}{p^t} \right)}{\partial p^t}.
\]  

as \( \frac{\partial h}{\partial p^t} = 0 \). From equations (6.21) and (6.18), one can see that \( \frac{\partial h}{\partial p^t} = \frac{1}{2p^t} = \frac{1}{2p^t} \) so that:

\[
\frac{\partial \ln \left( \frac{1}{p^t} \right)}{\partial p^t} = \frac{1}{\frac{1}{y + (1 - y) q^t_{t+1}} - \frac{1}{1 - y}} = \frac{1}{\frac{1}{2p^t} + \frac{1}{2p^t}} = \frac{1}{\frac{1}{1 + y + (1 - y) q^t_{t+1}} - \frac{1}{1 - y}}.
\]

Summarizing the above leads to
\[
\frac{\partial \ln q^t_{t+1}}{\partial p^t} = -\frac{\sigma_{xx} - \sigma_{xx}h'(\tau_{*,t+1})}{\sigma^2} \frac{2}{p^t} + \frac{1}{\frac{1}{y + (1 - y) q^t_{t+1}} - \frac{1}{1 - y}} \frac{1 - y}{p^t}.
\]

6.7.2 Derivative of \( q^t_{t+1} \) and \( q^t_{t+1} \) with respect to \( p^t_{t+1} \).

First of all, because of static expectations we have that \( \frac{\partial q^t_{t+1}}{\partial p^t_{t+1}} = 0 \). Second, as
\[
\ln q^t_{t+1} = \ln a + \xi_t + \ln k^t + \ln p^t_{t+1} + E_{t+1} \ln \theta^t,
\]
we have that,
\[ \frac{\partial \ln q_{t+1}^z}{\partial p_t^z} = \frac{\partial \ln p_{t+1}^z}{\partial p_t^z} + \frac{\partial \mathbf{E}_{t+1} \ln \theta^z}{\partial p_t^z} + \frac{\partial \ln \left( p_{t+1}^{su,z} + y p_{t+1}^{lu,z} \right)}{\partial p_t^z} \]  

(A6.9)

Now \( \frac{\partial \ln p_{t+1}^z}{\partial p_t^z} = 0 \), since the price in sector \( z \) does not change because of change in the price in sector \( x \).

As before, we have that

\[ \frac{\partial \mathbf{E}_{t+1} \ln \theta^z}{\partial p_t^z} = \frac{\partial \mathbf{E}_{t+1} \ln \theta^z}{\partial \mathbf{E}_{t+1} \ln \beta_{z,t+1}^z} \frac{\partial \mathbf{E}_{t+1} \ln \beta_{z,t+1}^z}{\partial p_t^z} \]  

(A6.10)

From Heckman and Honoré (1990) we have

\[ \frac{\partial \mathbf{E}_{t+1} \ln \theta^z}{\partial \ln \mathbf{E}_{t+1} \beta_{z,t+1}^z} = \frac{\partial \mathbf{E}_{t+1} \ln \theta^z}{\partial \ln \mathbf{E}_{t+1} \beta_{z,t+1}^z} = \frac{\sigma_{zz} - \sigma_{zx}h'(-c_{z,t+1})}{\sigma^2} h(-c_{z,t+1}), \]  

(A6.11)

where

\[ c_{z,t+1} = \frac{\mathbf{E}_{t+1} \beta_{z,t+1}^z}{\mathbf{E}_{t+1} \beta_{z,t+1}^z} + \mu_z - \mu_x \]

\[ c_{z,t+1}^* = \frac{c_{z,t+1}}{\sigma} \]

\[ h(-c_{z}) := \frac{1}{\Phi(c_{z}) \sqrt{2\pi}} e^{-\frac{1}{2}c_{z}^2} \]

From (A6.3) we have \( \frac{\partial \mathbf{E}_{t+1} \ln \theta^z}{\partial p_t^z} = \frac{2}{\nu_t^z} \). As a consequence, this leaves us with determining \( \frac{\partial \ln \left( p_{t+1}^{su,z} + y p_{t+1}^{lu,z} \right)}{\partial p_t^z} \). First, we rewrite this expression using (A6.6) for sector \( z \), yielding

\[ \frac{\partial \ln \left( p_{t+1}^{su,z} + y p_{t+1}^{lu,z} \right)}{\partial p_t^z} = \frac{1}{y + (1 - y) p_{t+1}^{su,z}} (1 - y) \frac{\partial p_{t+1}^{su,z}}{\partial p_t^z}. \]  

(A6.12)

which leaves us with determining \( \frac{\partial p_{t+1}^{su,z}}{\partial p_t^z} \).

Substituting (6.21) into (6.22) gives

\[ p_{t+1}^{su,z} = \frac{1}{2} \frac{L_{t+1}^z + L_t^z q_t^z}{L_{t+1}^z} + \frac{1}{2} (1 + q_t^z) \frac{L_{t+1}^z - L_t^z}{L_{t+1}^z}. \]  

(A6.13)

Notice that if \( q_t^z = q_t^z \), then \( p_{t+1}^{su,z} = \frac{1}{2} (1 + q_t^z) \) and \( p_{t+1}^{lu,z} = \frac{1}{2} (1 - q_t^z) \). In general, we have to determine the derivatives of both parts of the expression. First,

\[ \frac{\partial}{\partial p_t^z} \left[ \frac{L_{t+1}^z + L_t^z q_t^z}{L_{t+1}^z} \right] = \frac{L_{t+1}^z \left( \frac{\partial L_t^z}{\partial p_t^z} + \frac{\partial L_t^z}{\partial p_t^z} q_t^z + \frac{\partial q_t^z}{\partial p_t^z} L_t^z \right)}{(L_{t+1}^z)^2} - (L_{t+1}^z + L_t^z q_t^z) \frac{\partial L_{t+1}^z}{\partial p_t^z} \]  

(A6.14)
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Now

\[
\frac{\partial L_i}{\partial p_t^z} = \frac{\partial 2L\lambda_i^z}{\partial p_t^z} = 2L \frac{\partial \lambda_i^z}{\partial p_t^z}, \quad (A6.15)
\]

and

\[
\lambda_i^z = \int_0^\infty \int_0^\infty f(\theta^x, \theta^z) d\theta^x d\theta^z, \quad (A6.16)
\]

where \( E_\beta^j_t = E p_i^t E q_t^j = p_{t-1} q_{t-1}^j = \beta_{t-1}, j = x, z \). Thus we have,

\[
\lambda_i^z = \int_0^\infty \int_0^\infty f(\theta^x, \theta^z) d\theta^x d\theta^z, \quad (A6.17)
\]

which is independent of \( p_t^z \) and therefore,

\[
\frac{\partial L_i}{\partial p_t^z} = 2L \frac{\partial \lambda_i^z}{\partial p_t^z} = 0 \quad (A6.18)
\]

Now given this and \( \frac{\partial q_t^j}{\partial p_t^z} = 0 \), the expression \[
\frac{\partial}{\partial p_t^z} \left[ L_i^z + L_i^q \right]\]

can be reduced to:

\[
\frac{\partial}{\partial p_t^z} \left[ L_i^z + L_i^q \right] = - \frac{L_i^z}{(L_i^z + 1)} (1 + q_t^i) \frac{\partial L_i^{t+1}}{\partial p_t^z} \]

We are left with determining,

\[
\frac{\partial L_i^{t+1}}{\partial p_t^z} = \frac{\partial 2L\lambda_i^{t+1}}{\partial p_t^z} = 2L \frac{\partial \lambda_i^{t+1}}{\partial p_t^z} \quad (A6.19)
\]

From (A6.17) it follows immediately that,

\[
\frac{\partial \lambda_i^{t+1}}{\partial p_t^z} = \int_0^\infty \int_0^\infty f(\theta^x, \theta^z) d\theta^x d\theta^z \quad (A6.20)
\]

which can be rewritten as,

\[
\frac{\partial \lambda_i^{t+1}}{\partial p_t^z} = \int_0^\infty \int_0^\infty f(\theta^x, \theta^z) d\theta^x d\theta^z \quad (A6.21)
\]

Integrating with respect to \( \theta^z \) yields,

\[
\frac{\partial \lambda_i^{t+1}}{\partial p_t^z} = \int_0^\infty \frac{\partial}{\partial p_t^z} \left[ F^x(p_t^z q_t^x, 0, \theta^z) - F^z(0, \theta^z) \right] d\theta^z =
\]
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\[ \int_0^\infty \frac{\partial}{\partial p_i^z} \left[ F^x \left( \frac{p_i^z q_i^z \theta^2}{p_i^z q_i^z}, \theta^z \right) \right] d\theta^z, \quad (A6.22) \]

as \( F^x(0, \theta^z) \) is not a function of \( p_i^z \). At this point, we choose not to rewrite this expression any further by substituting the multivariate lognormal cumulative density. So now we have,

\[ \frac{\partial L_{i+1}^z}{\partial p_i^z} = 2L \int_0^\infty \frac{\partial}{\partial p_i^z} \left[ F^x \left( \frac{p_i^z q_i^z \theta^2}{p_i^z q_i^z}, \theta^z \right) \right] d\theta^z, \quad (A6.23) \]

and thus:

\[ \frac{\partial}{\partial p_i^z} \left[ \frac{L_i^z + L_i^z q_i^z}{L_{i+1}^z} \right] = - \frac{L_i^z}{(L_{i+1}^z)^2} (1 + q_i^z) \frac{1}{2} \int_0^\infty \frac{\partial}{\partial p_i^z} \left[ F^x \left( \frac{p_i^z q_i^z \theta^2}{p_i^z q_i^z}, \theta^z \right) \right] d\theta^z \quad (A6.24) \]

Now we have to determine the second part of \( \frac{\partial p_i^{stz}}{\partial p_i^z} \),

\[ \frac{\partial}{\partial p_i^z} \left[ \frac{L_i^z + L_i^z q_i^z}{L_{i+1}^z} \right] \cdot \frac{1}{2} (1 + q_i^z) = \frac{1}{2} (1 + q_i^z) \frac{\partial}{\partial p_i^z} \frac{L_i^z + L_i^z q_i^z}{L_{i+1}^z} + \frac{1}{2} \frac{L_i^z + L_i^z q_i^z}{L_{i+1}^z} \frac{\partial q_i^z}{\partial p_i^z} \]

We have,

\[ \frac{\partial}{\partial p_i^z} \left[ \frac{L_i^z + L_i^z q_i^z}{L_{i+1}^z} \right] = \frac{L_i^z}{(L_{i+1}^z)^2} 2L \int_0^\infty \frac{\partial}{\partial p_i^z} \left[ F^x \left( \frac{p_i^z q_i^z \theta^2}{p_i^z q_i^z}, \theta^z \right) \right] d\theta^z \quad (A6.25) \]

and,

\[ \frac{1}{2} \frac{L_i^z + L_i^z q_i^z}{L_{i+1}^z} \frac{\partial q_i^z}{\partial p_i^z} = \frac{1}{2} \frac{L_i^z + L_i^z q_i^z}{L_{i+1}^z} \frac{\partial q_i^z}{\partial p_i^z} \]

As a result:

\[ \frac{\partial p_i^{stz}}{\partial p_i^z} = \frac{\partial}{\partial p_i^z} \left[ \frac{1}{2} \frac{L_i^z + L_i^z q_i^z}{L_{i+1}^z} + \frac{L_i^z + L_i^z q_i^z}{L_{i+1}^z} \frac{1}{2} (1 + q_i^z) \right] = \]
\[
\frac{1}{2} \frac{L_i}{(L_{i+1})^2} \left[ -(1 + q_i) \int_0^\infty \frac{\partial}{\partial q_i^x} \left[ F^x \left( \frac{p_i^x q_i^x}{p_i^x q_i^x}, \theta^x \right) \right] d\theta^x + \frac{1}{2p_i^2} \frac{L_{i+1} - L_i}{L_{i+1}} \right] + \frac{1}{2} \frac{L_i}{(L_{i+1})^2} (q_i - q_i) \int_0^\infty \frac{\partial}{\partial q_i^x} \left[ F^x \left( \frac{p_i^x q_i^x}{p_i^x q_i^x}, \theta^x \right) \right] d\theta^x + \frac{1}{2p_i^2} \frac{L_{i+1} - L_i}{L_{i+1}}. \quad (A6.26)
\]

In this expression we can distinguish three distinct influences of a negative change in \( p_i^x \) on \( p_{i+1}^{stu, z} \). First, there is the difference in matching probability between both sectors. A second effect can be ascribed to the number of workers moving from sector \( x \) to sector \( z \). Third, there is the effect of the (multivariate) distribution of productivity in the sectors.

Substituting (A6.13) and (A6.26) into (A6.12) now yields the result:

\[
\frac{\partial \ln \left( pr_{i+1}^{stu, z} + ypr_{i+1}^{ltu, z} \right)}{\partial p_i^x} = \frac{1 - y}{y + (1 - y) \left[ \frac{1}{2} \frac{L_i + L_{i+1}}{L_{i+1}} + \frac{1}{2} \frac{L_{i+1} - L_i}{L_{i+1}} \right]}
\]

\[
\left\{ \frac{1}{2} \frac{L_i}{(L_{i+1})^2} (q_i - q_i) \int_0^\infty \frac{\partial}{\partial q_i^x} \left[ F^x \left( \frac{p_i^x q_i^x}{p_i^x q_i^x}, \theta^x \right) \right] d\theta^x + \frac{1}{2p_i^2} \frac{L_{i+1} - L_i}{L_{i+1}} \right\}. \quad (A6.27)
\]

In other words, the movement of workers out of the agricultural sector and into the manufacturing sector does not affect the relative fractions of \( stu \) and \( ltu \) workers in each sector. We conclude by once more stating the result:

\[
\frac{\partial \ln q_{i+1}^x}{\partial p_i^x} = \frac{\sigma_{xx} - \sigma_{xx}}{\sigma^2} h(-c_{i+1}) \left\{ \frac{2}{p_i^x} \frac{\partial \ln \left( pr_{i+1}^{stu, z} + ypr_{i+1}^{ltu, z} \right)}{\partial p_i^x} \right\}
\]

\[
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