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Intersectoral Migration of Agricultural Labor Force and Business Cycles in Developing Countries

发展中国家的农业劳动力转移和经济周期

Auswanderungen der landwirtschaftlichen Arbeitskraefte und Konjunkturen in den Entwicklungslaendern

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经济发展文论 Jingji fazhan wenlun
Arbeitspapiere für Wirtschaftsentwicklung
Working Papers for Economic Development
同济大学中德学院经济发展研究所
Institut für Wirtschaftsentwicklung
Institute for Econommic Development

05/2009

国际标准刊号：ISSN No 1860 2207

The present paper is the Working Paper No. 402 of Stanford Center for International Development (SCID) issued first on November 30, 2009, then revised in March, 2010 and in January 2011. It is also accessible online as http://scid.stanford.edu/?q=system/files/shared/pubs/402_Hu revised.pdf.

Impressum
Jingji fazhan wenlun，Nr. 5/2009 vom 9. Dezember 2009
Arbeitspapiere für Wirtschaftsentwicklung/Working Papers for Economic Development
ISSN-Nr. 1860-2207
Herausgeber: Prof. Dr. Jingbei Hu
Redaktion: Prof. Dr. Jingbei Hu
Verlag: Verlag China Translation Bonn
Druck: Lehrstuhl für Volkswirtschaftslehre am Chinesisch-Deutschen Hochschulkolleg (CDHK), Shanghai, VR China
Jingji fazhan wenlun (Arbeitspapiere für Wirtschaftsentwicklung/Working Papers for Economic Development) ist das offizielle Organ des Lehrstuhls für Volkswirtschaftslehre und des Instituts für Wirtschaftsentwicklung am CDHK
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Intersectoral Migration of Agricultural Labor Force and Business Cycles in the Developing Countries

Jingbei Hu*

Third Version, January 2011

Abstract

This paper establishes a framework to analyze short-run macroeconomic cycles with intersectoral migrations of agricultural labor in the developing economies. It first defines indicators to measure the migration and finds some regular facts of migrations and its velocity and acceleration. A model of the labor and commodity markets is set up to investigate equilibrium mechanisms of intersectoral migration as well as fluctuations and adjustments of price and migration in response to shocks. It shows flexible prices and wage rates with labor mobility can lead to a new equilibrium, but the economy may experience booms and slowdowns with return migrations of agricultural labor.

Keywords: Short-run macroeconomics of the developing countries; measures of agricultural labor migration; facts of agricultural labor migration; business cycles with agricultural labor migration; China

JEL Classification No.: E32, O11, O41

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Intersectoral Migration of Agricultural Labor Force and Business Cycles in Developing Countries

Labor migration from precapitalist agriculture into capitalist nonagriculture is a striking character of modern economic growth, which particularly manifests itself in the decline of the share of labor force engaged in agriculture. The long-run declining trend of the share is well known after Clark (1940) and Kuznets (1966) and studied by Lewis (1954), Jorgenson (1961), Ranis and Fei (1961) in development economics and recently by Matsuyama (1992), Kongsamut, Rebelo and Xie (2001), Gollin, Parente and Rogerson (2002), Ngai and Pissarides (2007) and many others under the keyword “structural change”. The short-run fluctuations of the share, however, have attracted little attention in development and macroeconomic researches.[1] In a popular textbook on development economics (Perkins, Radelet, Snodgrass, et al., 2001: 3-6), for example, the authors introduce the reader to the discipline with a narrative of a young Malaysian girl who went from a poor village to a urban factory for much more income and worked for several years, and came with her savings back to the village after a recession hit the manufacturing industry. For the authors the return to village is the happy destination of the girl

[1] Academic efforts to combine business cycle with agriculture have a very long history. Cantillon (1755/1831), e.g., already points out the short-run fluctuations of food production and population growth, which was accepted by almost all classical economists (Hayek, 1931, XXVII). The most known effort was probably made by Jevons (1884) who argues that fluctuations in agricultural production may cause the business cycles. But the former is brought about by periodical explosions of the sunspots. In the United States, Sprague (1903), Andrew (1906) and Anderson (1927, 1931) find close combinations of business cycles with fluctuations in purchasing power of farmers in the United States, which, in turn, are dependent on harvests. To explain the economic crises in 1930s Keynes (1936: 205-206) determinately rejects this agricultural theory of business cycles. The theory has disappeared completely since then. Recently, however, there come new interests in it for understanding the business cycles in the pre-Great Depression era. See e.g., Miron (1986), Davis, Hanes and Rhode (2009). But this theoretical line does not address the role the intersectoral migration of agricultural labor may play in business cycles. One of the reasons for it can be that labor statistics of that period are not available to both the contemporary and today’s researchers. In another direction, Jerome (1926) explained the business cycles in the target countries have effects on international migration. Similar effects on internal migration, a substantial parts of which is migration between farm and nonfarm areas, are mentioned by Schultz (1945), Sjaastad (1962), e.g. Sjaastad (1962: 80) even put forward the question “migration: too much or too little?” and saw migration as an equilibrating mechanism. But they fail to address questions as how business cycles are influenced by labor migration out of agriculture.

and the end of the story, hence they do not deal with the migration in any forms further.[2] But most of migratory farmers prefer to remain in nonfarm employment. Indeed, the long-run trend of agricultural labor transferring into nonagriculture could not be understood without positive imaginations of nonfarm employments by the most of farmers. Why, however, must sometimes migratory "farmer-workers" be confronted with the return migration after several years' employment in the nonfarm sector? There may be several microeconomic reasons (Sjaastad 1962; Vandercamp, 1971), but also macroeconomic ones. For example, the recession that led to a broad downturn in industrial production in Malaysia certainly contributed to the girl's return decision according to the story above.

In fact, return migration has currently become a serious challenge to economic and social policy in some developing countries after the 2008 economic crisis compelled millions of migratory farmers to go back. It is reported, for example, that around 20 million migrated "farmers" lost their nonfarm jobs in China and had to return to their remote villages (Chen, 2009). While the main concern in the United States and Western Europe is unemployment, the wave of involuntary return migration of former farmers draws most attentions in e.g. China. A few figures may help highlight the difference. During the Great Depression unemployment in the United States reached 13 million in 1933 when total agricultural employment amounted to 10 million only. After the current financial crisis burst in September 2008, unemployment increased to nearly 9 million in the US at the end of 2008, while less than 2.2 million farmers still worked in agriculture (ERP, 2010: Table B35). But the official unemployment in China which does not contain laid-off migratory "farmer-workers" was far below 9 million in 2008 and did not reached an half of laid-off migratory farmer-workers, not to say that agricultural labor in China still surpassed 300 million in 2008 (NBSC, 2009a: Table 4-1). In my opinion, these migrant workers who were forced to return to countryside may also bear the heaviest burden of such a severe economic slowdown in China. The short-run macroeconomic analysis of business cycles has to

[2] Even the large volume of Development Macroeconomics by Agenor and Montiel (1999), e.g., neglects migratory fluctuations associated with business cycles almost completely. Two studies of Todaro (1969) and Harris and Todaro (1970), and a large stock of literature following them, study farmer's intersectoral migration interacted with urban unemployment, but not with business cycles.

integrate these migratory fluctuations into its framework and thereby help to explain them.

The present paper tries to show that the long-run declining trend of the agricultural labor share may, particularly during the periods of mass migration out of agriculture, take a wave-form with clearly different rapidity and even reverse movements in the short-run. That means the average and instantaneous velocity of the share's decline could not be the same and the short run fluctuations in the instantaneous velocity should be often-observed macroeconomic phenomena during the modern economic growth. Furthermore, fluctuations in migration, instead of unemployment, may be an intrinsic and significant part of business cycles and work as an "equilibrating mechanism" to exacerbate or mitigate their scales. In the following section we will define indicators to measure farmer out-migrations and velocities of decline in agricultural labor share. With these indicators some interesting and styled facts of the migration are clarified and illustrated in Section II. Section III sets up a model of labor and commodity markets and explains its equilibrium. In the subsequent Section IV equilibrium migration between two points of time will be investigated. Finally, we shall discuss relationships between migration and business cycles in China in Section V.

I. Measuring Migration of Agricultural Labor Force

We assume an economy of full employment with two sectors of agriculture and nonagriculture where nobody can work in both sectors at the same time. According to the "census survivor" technique used in the population research (Ferrie, 2006: 491), net immigration into a region is measured with the equation of $(I_{t-1,t} - E_{t-1,t})=(P_t - P_{t-1}) - (B_{t-1,t} - D_{t-1,t})$, where the five capital letters stand for immigration, emigration, population, birth and death respectively and t represents time. Given statistical series of P, net immigration will be known if data on (B-D) are available. In the same manner, true net migration of labor force out of agriculture, $\mathcal{M}$, between two points of time t-1 and t can be measured as follows [3]

[3] Todaro (1969) used S and its increment to represent urban labor and rural-urban migration and Harris and Todaro (1970) used N for labor and migration. The subsequent literature, however, makes use of M for

$$(1.1)\qquad \mathcal{M}_{t-1,t}=-(I^A_{t-1,t}-E^A_{t-1,t})=(L^A_{t-1}-L^A_t)+(B^A_{t-1,t}-D^A_{t-1,t})$$
$$=(L^A_{t-1}-L^A_t)+n^A_{t-1,t}L^A_{t-1}$$

where L stands for labor and n for natural rate of growth in labor, while superscript A denotes agriculture. B and D in (1.1) are understood as entrance into and exit from labor force resulting from demographic reasons between t-1 and t. In consideration of the long-run trend of labor transfers out of agriculture, we use $(L^A_{t-1}-L^A_t)$ in (1.1) instead of the common usage of $(L^A_t-L^A_{t-1})$ to ensure that $\mathcal{M}$ is positive in most cases. However, $\mathcal{M}$ is statistically unobservable because data on B^A and D^A or n^A are not available in accessible statistical publications at least at the national level. Thus we have to search after substitutes for $\mathcal{M}$. A possible one is M, defined as follows:

$$(1.2)\qquad M_{t-1,t}=(L^A_{t-1}-L^A_t)+n_{t-1,t}L^A_{t-1}$$

M indicates magnitude of out-migration of agricultural labor if $n^A_{t-1,t}=n_{t-1,t}$.[4] Given a closed economy, $n_{t-1,t}$ can be calculated without statistical ambiguity because data on L are generally available. Hence, M is an observable measure. However, the assumption of $n^A_{t-1,t}=n_{t-1,t}$ is too far from reality.[5] But this drawback will become much less severe if thinking of M in relative terms.

We define the so-called migration rate of labor out of agriculture, m, as follows [6]

$$(1.3)\qquad m_t=\frac{M_t}{L_t}$$

m measures net outmigration of agricultural labor relative to total labor if $n^A_{t-1,t}=n_{t-1,t}$. We also use t to denote the period of time between t-1 and t if no confusion occurs. m can be defined from another angle of view if observing the migration from the well-known decline of

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migration and m for migration rate, which Todaro (1976) followed, too. $\mathcal{M}_{t-1,t}$ can also be computed from changes in nonagricultural labor with $(L^N_t-L^N_{t-1})-n^N_{t-1,t}L^A_{t-1}$, where superscript N represents nonagriculture.

4 Literature of development economics often uses n instead of n^A to measure intersectoral migration of agriculture labor, see e.g. Todaro (1969), Mundlak (1979), Larson and Mundlak (1997). There are also a few papers in Chinese which compute migration with n, see Guo (2002), Chen and Li (2004), Li (2005).

5 Kuznets (1966: 124) estimated n^A may be three times of n for economies in the earlier phases of modern economic growth. Johnson (1960: 403) mentioned that the natural increase of the farm population might offset about two fifths of the net outmigration from farm to nonfarm areas in the United States during 1950s.

6 The concept of migration rate of agricultural labor has a long history in the post-war literature, see e.g., Todaro (1969), Mas-Colell (1973). Todaro (1969) defined the rate with M to urban labor, but replaced the latter with rural labor (Todaro, 1976). Mundlak (1979: 25) and Larson and Mundlak (1997) calculated migration with an equation essentially same to our Equation (1.2) and held m=M/L_1. In the literature reviewed by the Arthur of this paper the denominator of m is agricultural, rural or nonagricultural, urban labor and there are not papers found with our equation (1.3) and/or (1.4).

agricultural share of labor, $l_t = L^A_t / L_t$ [7]:

(1.4) $m_t \equiv \Delta l_t$

(1.4) points out that migration rate of agricultural labor at t is exactly equivalent to the velocity of the decline in l at t. (1.4) can be proved as follows. From the definition of Δl_t we know

$$\Delta l_t = l_{t-1} - l_t = \frac{L^A_{t-1}}{L_{t-1}} - \frac{L^A_t}{L_t}$$

Because $L_t = (1+n_{t-1,t})L_{t-1}$, we get

$$(1.5) \qquad \Delta l_t = \frac{L^A_{t-1}}{\frac{L_t}{1+n_t}} - \frac{L^A_t}{L_t} = \frac{1}{L_t}[(L^A_{t-1} - L^A_t) + n_t L^A_{t-1}] = \frac{M_t}{L_t}$$

$$= m_t$$

Therefore, m is merely a convenient representation for Δl since the both stand for the same ratio of outmigration of agricultural labor to total one which, in turn, equate velocity of the fall in l. While migration rate is a usage in short-run analysis and velocity of the share's decline is more adequate for long-run research, m expresses explicitly the juncture of the both aspects. We borrow a for acceleration of the fall in l from physics and express a by

$$(1.6) \qquad a_t \equiv \Delta m_t = m_t - m_{t-1} = \frac{M_t}{L_t} - \frac{M_{t-1}}{L_{t-1}}$$

Introducing $L_{t-1} = \frac{L_t}{1+n_t}$ into (1.6) to obtain

$$(1.7) \qquad a_t = \frac{M_t - (1+n_t)M_{t-1}}{L_t} = \frac{A_t}{L_t}$$

where $(1+n_t)M_{t-1}$ is the quantity of migration of agricultural labor during the period t whose growth rate is equal to that of total labor, while growth rates of agricultural and total labor are

[7] The literature usually uses concepts of sectoral shares of employment and also takes employment as the denominator for migration rate. We prefer total labor because it is less susceptible to business cycles than total employment. Another reason is that it makes m immediately comparable with change in unemployment rate in the short-run analysis for economies with massive labor migration out of agriculture since the both have the same denominators of total labor. Labor and employment share can be derived from each other through $l^E_t = l_t(1-u_t)$, where l^E_t stands for employment share and u_t for unemployment rate.

already assumed the same. A_t stands of the difference between M_t and this quantity. It is obvious that the value ranges of a_t depend on that of A_t. Take an example. Suppose L^A_{t-1}=100 (million, e.g.), L^A_t=95, M_{t-1}=5, L_t = 202, n_t = 1%, we have M_t=6, $(1+n_t)M_{t-1}$=5.05, then

$$A_t=M_t - (1+n_t)M_{t-1} = 0.95 > 0$$

Therefore,

$$a_t=\frac{A_t}{L_t} = 0.95/202= 0.47\% >0$$

$$m_{t-1} = 5/200 = 2.5\%$$

$$m_t = 6/202 = 2.97\%$$

This example makes clear that an increase in m or a >0 demands not only migration during the period t is greater than during t-1, but also greater than the last one plus the growth at the speed same to that of total labor growth. The economic meaning of it lies in that because migration velocity is computed with help of total labor and the latter is increasing, migration velocity can be accelerated only when growth rate of migration surpasses that of total labor. We will have a_t=0 if the both rates are equal, that is

$$M_t - (1+n_t)M_{t-1}=0$$

that is

$$(1.8) \qquad g_{M_t} = \frac{M_t - M_{t-1}}{M_{t-1}} = n_t$$

II. Some Facts of Fluctuations in Migration of Agricultural Labor

Foster and Rosenzweig (2008: 3054) recently complained the lack of data on migration of agricultural labor and found it one of the basic restrictions to migration researches. While recognizing this restriction, we try to arrange available data with the measures defined above. In fact, only with appropriate measures can these data, though often scarce and ambiguous, be processed for researchers and policymakers (Popper, 1960). We select the United States, [8] the most developed country of the world, and China, [9] the most populous country, for the empirical studies and reveal some facts of fluctuations in farmer migration in the two countries. The United States began modern economic growth with three quarters or more labor force in agriculture, successfully transferred almost all of them into nonagriculture during the last two centuries, while China now lies in the middle of the migration process. Our intention is not to compare the processes of the migration between the two countries, but to find some of its regularities at the national and even global levels which may be more generally valid.

(1) Inverse U-shaped pattern of change in L^A

We illustrate data of L^A in US from 1800 to 2009 and in China from 1952 to 2008 [10] in Fig.

[8] There are a plenty of legal and illegal foreign labor forces working in the US agriculture. During the fiscal year of 1994-1995. e.g., US citizen engaged in the US agriculture were less than a third of the total agriculture labor, while the illegal labor forces including ones whose residence statues were not clarified amounted to 39% (Mines, et al., 2010). We will make use of only the systematic data on US total and agricultural labor widely accepted by most US academics or published by the government and do not take these foreign labor into account.

[9] There are only official statistics available in China beginning with 1949 or a few years later which have been checked and criticized widely by international and Chinese researchers. In fact, there are many clear inconsistencies in the Chinese labor statistics. Nan and Xue (2002) investigated China's population and labor statistics and set up their own data series. To the recent researches on quality of Chinese statistics in general, see e.g., Young (2003) and Holz (2005). This section uses China's official statistics without consideration of its inconsistencies.

[10] China's official labor statistics begin with 1952, with which we shall calculate l, m and a in this section. But the first generation of the capitalist business set up by the Chinese with modern technology began at least in 1870s. Some economic historians estimated l=0.80 in China already in 1887 (Wang, 2004: 107). A nationwide investigation in 1933 found 47.5% of all single peasants who left their villages came to urban areas for nonagricultural employment (Agricultural Report, vol. 4: 178).

2.1. It shows that L^A first rises after modern economic growth or the transition began there, and then, maybe around 100 years after, decreases. US entered the decreasing phase of L^A in the first decade of the 20 century and China in the last one. An inverse U-shaped curve may well fit the long-run trend of L^A in both countries.

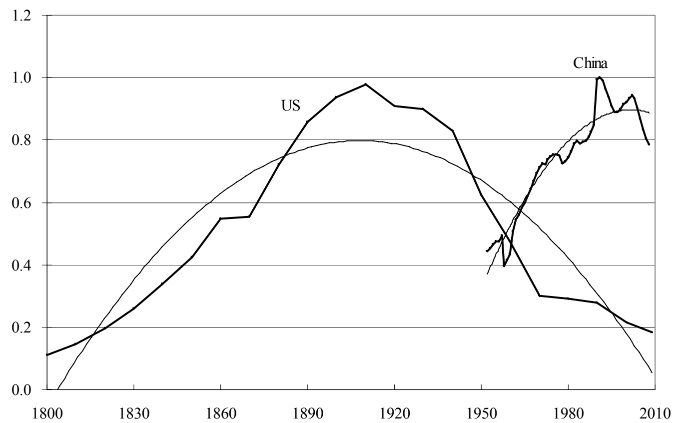

Fig. 2.1 Trend of L^A in the United States, 1800-2009, and in China, 1952-2008

Note: Percentage of the maximums of L^A which are normalized to 1. US maximum of L^A was 11,493 thousand in 1907 according to Weir (1992, cited from Carter, et al., eds., 2006, Table Ba472), while China's figure was 390,980 thousand in 1991 (NSBC, 2010, Table 1-4).

Sources: US decennial data of the census years from 1800 to 1880: Weiss, 1992; 1993, cited from Carter, et al., eds., 2006, Table Ba830; from 1890 to 1900: average of data from Weiss, 1993, cited as above, and that from Weir, 1992, cited from Carter, et al., eds., 2006, Table Ba472; from 1910 to 1980: Weir, 1992, cited as above; of 1990: average of data from Weir, 1992, cited as above, and that from ERP, 2010, Table B35; from 2000 to 2009: ERP, cited as above. China annual data: NBSC, 2010, Table 1-4.

(2) Declining trend of *l*

The robustly declining trend of *l* in US is depicted with decennial data from 1800 to 2009 in Fig. 2.2 and with annual data from 1890 to 2009 in Fig 2.3 where Chinese annual data on *l* from 1952 to 2008 are shown as well. The graphs validate one of the well-known Kuznets styled facts of *l*'s long-term decline. They also suggest that the velocity of the decline is full of fluctuations.

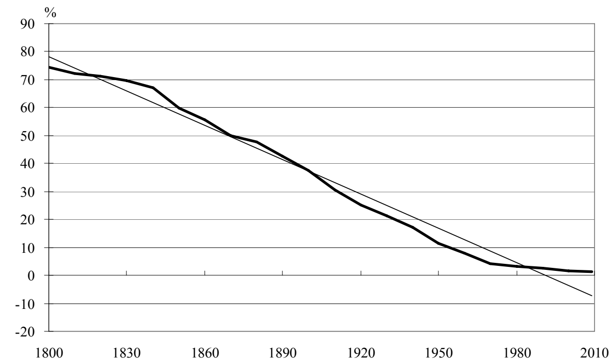

Fig. 2.2 Decennial decline of *l* in the United States, 1800-2009

Sources: Decennial data from as of Fig. 2.1 and also Table Ba829 for Weiss' dataset and Table Ba470 for Weir's dataset for the computation of *l*.

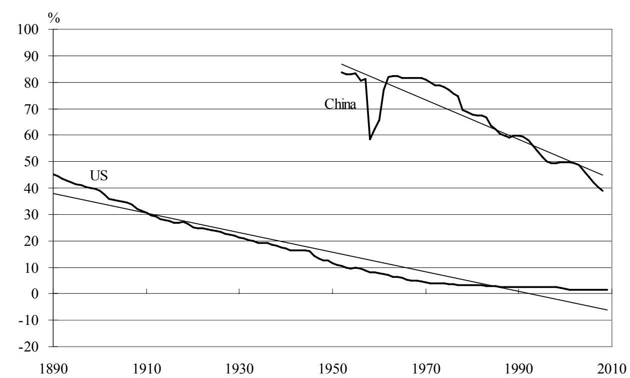

Fig. 2.3 Annual decline of *l* in United States, 1890 to 2009, and in China, 1952-2008

Sources: US data from 1890 to 1989: Weir, 1992, cited as of Fig. 2.1 and 2.2; of 1990: average of data from Weir, 1992, cited as above, and that from ERP, 2010, Table B35; from 1991 to 2009: ERP, 2010, Table B35. China's data: as of Fig. 2.1.

(3) Inverse U-shaped Pattern of *m*

Looking at graphs in Fig. 2.2 and 2.3 more detailedly, we find that *l* may decline at the speed that changes systematically. If we divide the whole process of the decline in *l* in three phases of the early, middle and late ones, *l* may decline more slowly in the first and third phases, but more quickly in the middle one, meaning *m* has a time path of a low-high-low or an inversed U-shaped pattern. The pattern is already shown in Fig. 2.2 where the graph of *l* intersects its trend line from left under in the early and late phases while crossing it from right above in the middle phase.

This imagination of an inverse U-shaped pattern of *m* can be supported with immediate data on *m*. The graph of *m* in US from 1810 to 2009 in Fig. 2.4 may conceal its annual changes, but still show its inverse U-shaped pattern in the long run: *m* first rises, then declines and finally tends to zero. The US annual data on *m* from 1891 to 2009 are depicted in Fig. 2.5 where *m* is doubtless decreasing during the whole period of 119 years which consists of only the middle and late phases of the decline process in US.

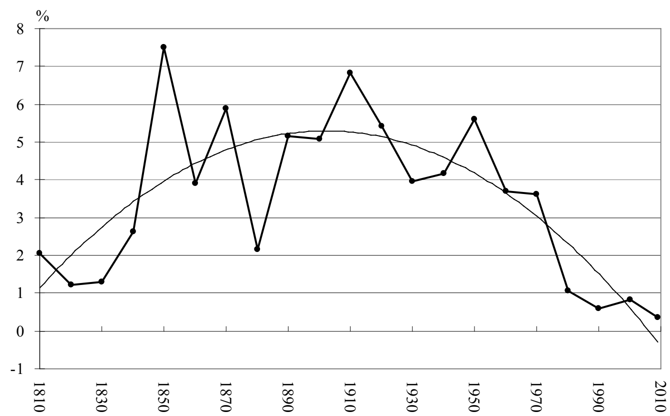

Fig. 2.4 *m* and its trend the United States, 1810 to 2009

Sources: Decennial data from as of Fig. 2.2.

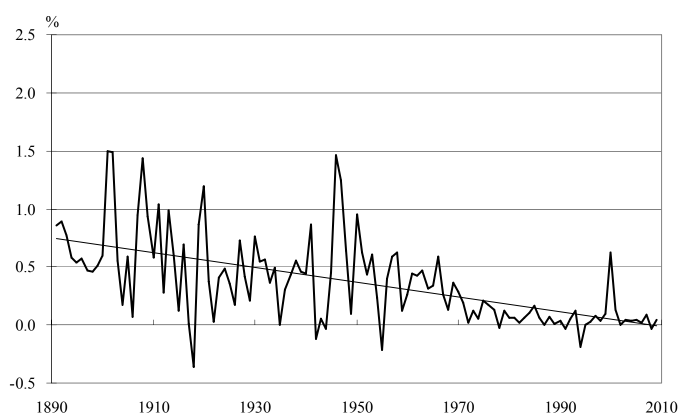

Fig. 2.5 *m* and its trend in the United States, 1891 to 2009

Sources: As of Fig. 2.3.

In contrast to US illustrated in Fig. 2.5, China experienced an increasing *m* from 1953 to 2008 when it lay in the early and middle phases of the transition. Although *m* reached the world-historically highest level of 23% in 1958 in China's early phase, the linear trend of *m* for the whole period of 56 years is clearly increasing, supporting again our imagination of the inverse U-shaped pattern of *m*. It is to expect that *m* will turn to decrease in China in the future when there will be less and less labor force still engaged in agriculture which functions as a reservoir whose outflow is the migration we concern with.

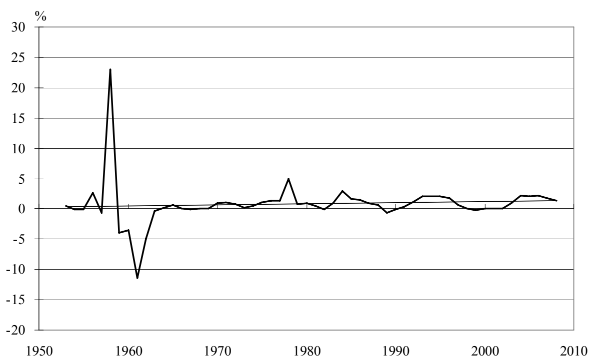

Fig. 2.6 *m* in China, 1953 to 2008

Source: as of Fig. 2.1.

(4) Fluctuations of *m* and *a* in the short run

The last three figures have already shown that *m* changes frequently and strongly in US as well as China. The usual frequency and amplitude of fluctuations in *m* in China become clearer in Fig. 2.7 without its abnormally acute turbulences from 1958 to 1963. There is even a clearly cyclical pattern of *m* at least since around 1980 when China began its far-reaching economic reforms and its peasants won back their right to migrate out for nonagricultural employment.

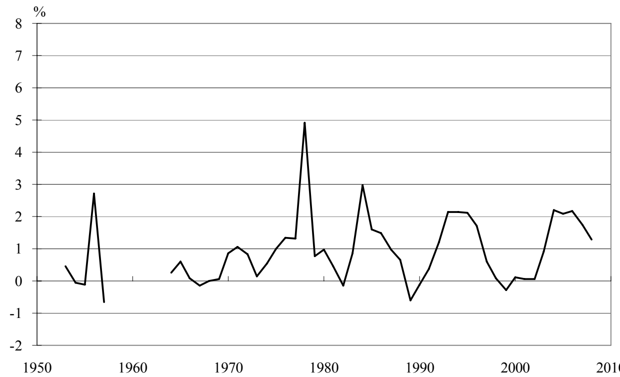

Fig. 2.7 Fluctuations in *m* in China, 1953 to 2008 without 1958-1963

Source: as of Fig. 2.1.

As same as *m*, *a* also changes frequently and strongly in China as illustrated in Fig. 2.8 for the whole period of 55 years and in Fig. 2.9 without the years from 1958 to 1963. The amplitude of *a* even exceeds the benchmark of 1 percentage point sometimes. The US annual data show, especially before 1960, the similar pattern of frequency and amplitude of changes in *a* in Fig. 2.10. Strong fluctuations in *m* and *a* imply they may be of importance for short-run macroeconomic performance. An example can highlight it. *m* is comparable to difference of unemployment rate, Δu, since their numerators are flows and their denominators are the same. We illustrate growth rate of China's GDP, *g*, and its *m* and Δu from 1979 to 2008 in Fig. 2.11. It shows that fluctuations in *m* were clearly more relevant to that of *g* than Δu did at least because $|\Delta u|$ was quantitatively too small to compete with *m* during the period.[11]

[11] There is an econometrical study in China (Zhang, 2010) that pointed out only two factors, growth rate of capital formation and migration rate, also *m* in this paper, have effects on that of the GDP during China's reform period from 1979 to 2008 and effects of all other factors inclusive the unemployment variable considered in the study are insignificant.

Fig. 2.8 Fluctuations in a in China, 1954 to 2008

Source: as of Fig. 2.1.

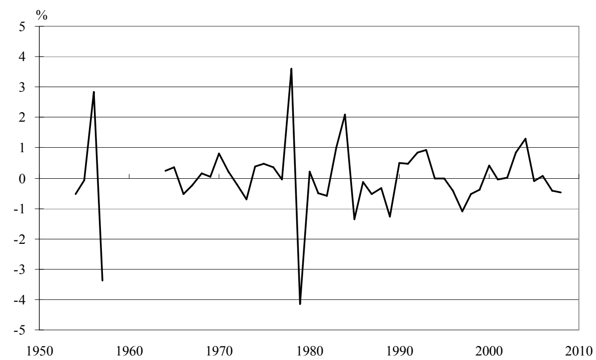

Fig. 2.9 Fluctuations in a in China, 1954 to 2008 without 1958-1963

Sources: as of Fig. 2.1.

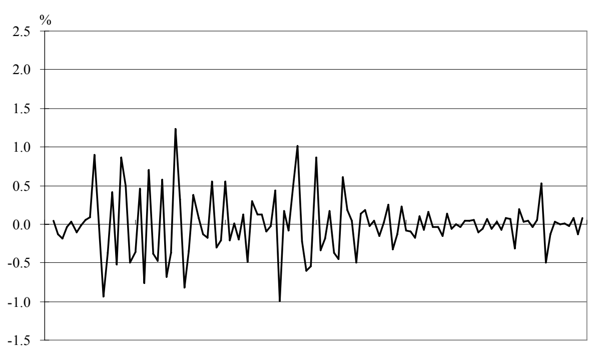

Fig. 2.10 Fluctuations in a in US, 1892 to 2009

Sources: as of Fig. 2.3.

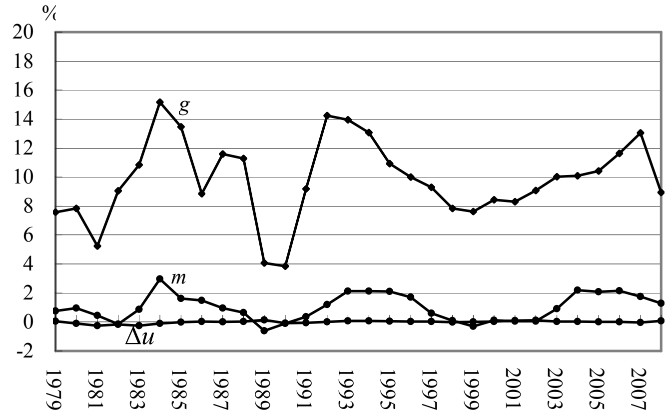

Fig. 2.11 g, m and Δu in China, 1979 to 2008

Note: China's official statistics of unemployment began with 1978. We calculate U/L and get Δu through $(U_t/L_t)-(U_{t-1}/L_{t-1})$. g is calculated at constant price.

Sources: m and Δu: as of Fig. 2.1. g: NSBC, 2010, Table 1-8.

(5) Difference across countries

In order to comparing differences in l, m and a across countries, here particularly between US and China, the three phases of the transition mentioned above should be more clearly divided. We define the middle phase as a between-period beginning with the first entire decade of $m \geq 5.0$ and ending with the last decade of $m \geq 5.0$, in both cases l does not rise back essentially after. Accordingly, some differences between US and China may be captured as in Table 2.1.

Table 2.1 Some differences in the decline of *l* between US and China

	US	China
Beginning of the early phase	1800	1870
Beginning of the middle phase	1840	1970
Rapidity in the middle phase: annual average of *m*	0.51 (1840-1950)	1.10 (1970-2008)
Stability: range of decennial *a*	-3.74, 4.90 (1820-2000)	-32.81, 27.91 (1954-2008) *
range of annual *a*	-0.99, 1.23 (1892-2009)	-26.93, 23.66 (1954-2008)

*: The reference years are 1954, 1960, 1970, 1980, 1990, 2000 and 2008.

Sources: as of Fig. 2.1, 2.2 and 2.3.

What we can say about cross-national differences in the decline in *l* from Table 2.1 may be as follows: (a) Some countries begin the transition earlier while some much later. (b) The early phase of the transition is short in some countries while long or very long in some other ones. (c) As a result from the two differences, some countries begin the middle phase earlier while some much later. (d) Countries entering into the middle phase later may have higher *m* than countries beginning their middle phase earlier. (e) Countries entering into the middle phase later may have a wider range of *a* than countries. (f) There are large gaps in *l*, *m* and *a* across the countries at a certain time point or period after the human being began its transition out of agriculture around 300 years ago.

III. A Model for the Labor and Goods Markets [12]

The findings described above challenge economists with many questions. We are concerning here only with the rapidity and stability of the decline in *l*. Fig. 2.2 and 2.3 have shown *l* declines more rapidly and less stably in China than in US where *l* seems to be more in free fall in the long run. The decline of *l* is similar to the landing of a plane. For the passengers in the plane security or stability is dominant since any strong turbulences resulting from the pilot's landing plans may hurt or kill. However, the plane should land as fast as possible in order to escape from security dangers in the sky finally. The optimal solution for the landing should be a combination of desired rapidity and stability. The optimal solution for the decline in *l* also should be a combination of desired *m* and *a* where the both measure rapidity and stability of the decline, respectively. Obviously, the bigger *m* and the smaller $|a|$ is, the more quickly and stably *l* will decline. In the short run, stability is even more important than rapidity. In fact, a big famine which demanded at least around 20 millions human lives in China around 1960 followed the forced outmigration of agricultural labor for the national industrialization plan known as "Great Leap-Forward" in 1958 when China's *m* and *a* once reached 23 and 23.66 percentage points, respectively.[13] The tragedy sharply shows the necessity of tradeoff between rapidity and stability of the decline in *l* for the mankind remaining in the process of *l*'s decline.

Before to address questions of rapidity and stability of *l*'s decline and their tradeoff, we have to know about equilibriums of *l*, *m* and *a*. This and the following section will try to set up a short-run macroeconomic framework to analyze equilibriums of *l* and *m*. Therefore we accept the common assumptions about the short-run, that is, constant total amount of capital and labor, fixed sectoral allocation of capital as well as given technology and institutions. Furthermore, it is

[12] Many contents, especially the model and Table 3.2, of this section were published in Chinese in Hu (2008).

[13] In the Chinese official statistics there are time series of data on total population and its growth rate from 1949, sometimes in the same table. However, both data for the years 1958 to 1963 have been openly and severely inconsistent, see e.g. NSBC, 2005, Table 3; 2009, Table 1-3. Nevertheless, even the lowest estimation from these official data suggests a magnitude of around 20 million persons who died from starvation during the period.

assumed that:

(1) The economy consists of non-capitalist agriculture and capitalist nonagriculture;

(2) Much higher productivity in nonagriculture than in agriculture;

(3) Nobody involves in both sectors at the same time;

(4) Full employment;

(5) Migration takes no time;

(6) Single-family, that is, each family has only one member who is a worker.

The first assumption clearly implies that we take the approach of dual economy developed by Lewis (1954) to analyze intersectoral migration of agricultural labor and leave the mainstream research on structural change which assumes all sectors in the reference economy are capitalist. Agriculture plays a role in the mainstream research similar to any other sectors and can be replaced with another sector, e.g., iron and steel or energy industry, provided its production must match a minimum demand or its income elasticity or technological change has certain particularities (See. e.g. Baumol, 1967).[14] We assume a non-capitalist agriculture to take into account the history of the human transition out of agriculture in the long run as well as the present institutional backgrounds of agriculture for the short run analysis.[15] In the non-capitalist agriculture farmers assign their net output exclusively to labor they use in production, but not to capital and other production factors. However, in contrast to capitalist nonagriculture where the neoclassical structure makes the standard long for most of economists, there may not be a widely-accepted setting of the non-capitalist agriculture. Hu (1994, 1998) supposes a

[14] Some mainstream studies on structural changes do not include changes in agriculture consciously (Acemoglu and Guerrieri, 2008).

[15] Some scholars argue that agriculture still remains non-capitalist even in today's developed countries because of the domination of family farms using labor forces mainly from within the family of the farm owners or managers who rent in farm (Allen and Lueck, 2003; Friedman, 1978; Hill, 1993). Another important reason for agriculture remaining non-capitalist may be very low productivity relative to that of nonagriculture as expressed in the assumption (2). According to Maddison (1970) and Restuccia, Yang and Zhu (2008), average product of farm labor is only around a fifth of that of nonfarm labor in the most of countries they studied. With the average productivity gap in such a big scale, the gap of marginal products of labor between the two sectors should be even bigger. Let MP and AP stand for average and marginal product, respectively, and normalize AP^N to 1, we may have MP^N=0.6, AP^A=0.2 and MP^A=0.08. In fact, the non-capitalist-agriculture assumption is an escape from facing questions such as why there are still labor forces in agriculture receiving much lower income than the average of a nation. Barro (1997, Chapter 5) explained why the assumption (2) about productivity gap is not compatible with the neoclassical approach.

community-family agricultural structure in which use-right of total arable land of the community is distributed to its farm families according to the population principle. No tenure exists. If a farmer migrates out, his land will be redistributed among remaining community families. He can get land to use again if returning to the community. A farmer's income corresponds to all product of the land he cultivates and the so-called agricultural wage rate corresponds to average product of labor. The wage rate may equal to or exceed the subsistence level. However, it will increase, as soon as some farmers migrate out of the community and leave their land to be cultivated by the remainders freely, and become higher than the subsistence level in case it was at that level earlier. The well-known horizontal wage curve proposed by Lewis (1954) does not apply, irrespective of how low the marginal product of agricultural labor could be, provided it is positive. The concept of average-product wage means exactly that the whole net product of the land including those that will be assigned to land and capital in a capitalist sector is held as returns to only labor inputted. Two of the analytical implications of this "non-capitalist agricultural wage" should be made explicit. The first one is that this wage can fluctuate as workers migrate between farm and nonfarm sectors in response to market changes.[16] Another implication lies in that farmers compare it with nonfarm wage in making decisions upon their intersectoral migrations, although the latter is determined by the marginalistic principle.

Based on this agricultural setting and the standard neoclassical structure in nonagriculture, we model short-run labor and commodity markets as follows:

(3.1) $\mathrm{Y} = p\mathrm{Y}^{\mathrm{A}}+\mathrm{Y}^{\mathrm{N}}$

(3.2) $\mathrm{Y}^{\mathrm{A}}=f^{\mathrm{A}}(\theta\mathrm{K}, l\mathrm{L})$

(3.3) $\mathrm{Y}^{\mathrm{N}}=f^{\mathrm{N}}[(1-\theta)\mathrm{K}, (1-l)\mathrm{L}]$

(3.4) $w^{\mathrm{A}} = \dfrac{f^{\mathrm{A}}}{l\mathrm{L}}$

[16] Other concepts of agricultural wage known in development economics as Lewis' subsistence wage (1954), Fei and Ranis' constant institutional wage (1964) are impossible to be integrated in a short-run analysis since they are not allowed to change flexibly. Recent mainstream researches on long-term structural change make use of marginal-product wage for agriculture which changes in the course of technological progress and consumer's preference shift.

$$(3.5)\qquad w^{\mathrm{N}} = \frac{\mathrm{d}f^{\mathrm{N}}}{\mathrm{d}[(1-l)\mathrm{L}]}$$

$$(3.6)\qquad pw^{\mathrm{A}} = w^{\mathrm{N}}$$

$$(3.7)\qquad p\mathrm{Y}^{\mathrm{A}} = c\mathrm{Y},$$

$$(3.8)\qquad \mathrm{L} = \mathrm{L}^{\sim}$$

$$(3.9)\qquad \mathrm{K} = \mathrm{K}^{\sim}$$

$$(3.10)\qquad \theta = \theta^{\sim}$$

$$(3.11)\qquad c = c^{\sim} \qquad\qquad (^{\sim} \text{ means a constant})$$

where Y, K and w stand for output, capital and wage rate, respectively, and p (>0) for relative price of farm product with nonfarm product being the numeraire, while $\theta \in (0, 1)$ denotes ratio of capital stock in farm sector to total capital and $c \in (0, 1)$ is a variant of Engel's coefficient. We omit the signs for time since we deal with static equilibrium here. Questions about the optimization of equilibriums, if they exist, will not be considered explicitly. Hence no utility function is listed in the model. Assuming f^{i} are continuous and differentiable at least two times and satisfy the Inada conditions including $(f^{\mathrm{i}})'>0$ and $(f^{\mathrm{i}})''<0$, i=A, N. Equation (3.6) and (3.7) are equilibrium conditions for labor and farm-product markets, respectively. Our model economy still has a market for nonfarm product. However, it can be abstracted from the analysis because Walras' law applies. Changes in p are caused by fluctuations in demand for and supply of farm product. We suppose that the economy concerned is so developed that it has passed through the so called phase of subsistence. In our economy, farm product an individual consumes is clearly more than for mere subsistence, even when one has to reduce one's food consumption because of decreases in one's income and/or increases in p. Based on this supposition, how much farm product an individual consumes will depend on one's preference, income and prices. In the short run, preference is assumed constant and a fixed part, c, of one's income may be allocated for consumption of farm product. In aggregate we have cY in place of the demand function for farm product, $\mathrm{Y}^{\mathrm{A,D}}$, with

$$(3.12)\qquad c = c(\mathrm{Y}), \qquad\qquad \frac{\mathrm{d}c}{\mathrm{dY}} < 0,\ 1 > c > \frac{\mathrm{d}p\mathrm{Y}^{\mathrm{A,D}}}{\mathrm{d}c}\left|\frac{\mathrm{d}c}{\mathrm{dY}}\right| > 0$$

The inequality c>(dpY^{A,D}/dc)(|dc/dY|) implies that pY^{A,D} will increase as soon as Y rises. The supply of farm product is given by farm production function (3.2) at p. Our model consists of eleven equations with seven unknowns (Y, Y^{A}, Y^{N}, p, l, w^{A}, w^{N}) and four parameters (θ, K, L, c). Let look at labor market first. Introducing (3.4) and (3.5) into (3.6) and solving for p gives

$$\text{(3.13)} \quad p^{L} = \frac{l\mathrm{L}}{f^{A}} \frac{\mathrm{d}f^{N}}{\mathrm{d}[(1-l)\mathrm{L}]}.$$

where superscript L denotes labor market. Differentiating (3.13) with respect to l will obtain

$$\text{(3.14)} \quad \frac{\mathrm{d}p^{L}}{\mathrm{d}l} = \frac{\mathrm{L}}{(f^{A})^{2}}\left(f^{A} - l\mathrm{L}\frac{\mathrm{d}f^{A}}{\mathrm{d}(l\mathrm{L})}\right)\frac{\mathrm{d}f^{N}}{\mathrm{d}[(1-l)\mathrm{L}]} - \frac{l\mathrm{L}^{2}}{f^{A}}\frac{\mathrm{d}f^{N,2}}{\mathrm{d}[(1-l)\mathrm{L}]^{2}} > 0$$

since

$$f^{A} - l\mathrm{L}\frac{\mathrm{d}f^{A}}{\mathrm{d}(l\mathrm{L})} > 0, \quad \frac{\mathrm{d}f^{N,2}}{\mathrm{d}[(1-l)\mathrm{L}]^{2}} < 0.$$

For the goods market we rewritten (3.7) as follows

$$p^{G}\mathrm{Y}^{A} = c(p^{G}\mathrm{Y}^{A} + \mathrm{Y}^{N}) = cp^{G}\mathrm{Y}^{A} + c\mathrm{Y}^{N}$$

where superscript G represents goods market. Rearranging it and solving for p^{G} to get

$$\text{(3.15)} \quad p^{G} = \gamma\frac{\mathrm{Y}^{N}}{\mathrm{Y}^{A}} = \gamma\frac{f^{N}}{f^{A}}$$

where $\gamma = c/(1-c)$, $\gamma > 0$, dγ/dc>0. Differentiating (3.15) with respect to l gives

$$\text{(3.16)} \quad \frac{\mathrm{d}p^{G}}{\mathrm{d}l} = -\gamma f^{N}\frac{1}{(f^{A})^{2}}\frac{\mathrm{d}f^{A}}{\mathrm{d}(l\mathrm{L})}\mathrm{L} - \gamma\frac{1}{f^{A}}\frac{\mathrm{d}f^{N}}{\mathrm{d}[(1-l)\mathrm{L}]}\mathrm{L}$$

$$= -\gamma\mathrm{L}\frac{1}{(f^{A})^{2}}\left\{f^{N}\frac{\mathrm{d}f^{A}}{\mathrm{d}(l\mathrm{L})} + f^{A}\frac{\mathrm{d}f^{N}}{\mathrm{d}[(1-l)\mathrm{L}]}\right\} < 0$$

because {·}>0. Without lose of generality, we draw two lines of p^{L} and p^{G} in Fig. 3.1 with $p^{L}(l)$ running upwards and $p^{G}(l)$ downwards. Fig. 3.1 shows, on the one hand, that p^{L} has to rise to maintain $p^{L}w^{A}=w^{N}$ in labor market if more labor is employed in agriculture since higher l implies lower w^{A} and higher w^{N}. On the other hand, higher l will produce more farm product when restraining increases in aggregate output, which will lead to fall in p^{G} to balance the demand and supply in goods market. Therefore, the level of price for maintaining labor market in equilibrium, p^{L}, will be higher than that of p^{G} for clearing goods market if $l=l^{\#}$ in Fig. 3.1. In the opposite case, p^{L} will be lower than p^{G} if $l=l^{*}$. In both the cases, no markets can equilibrate and the economy fluctuates. But changes in p and l will bring the two markets in equilibrium at the same time. If, e.g., the economy happens at $l=l^{\#}$, p^{L} cannot rise high enough to prevent farm labor forces from migrating out because of decreasing p^{G}, so l will fall. Otherwise, l will go up from the point of $l=l^{*}$ because p^{L} cannot fall enough to hold $p^{L}w^{A}=w^{N}$ for keeping nonfarm labor in remaining in face of increasing p^{G}. Taking p^{L} and p^{G} into an equation and rearranging the terms, we get

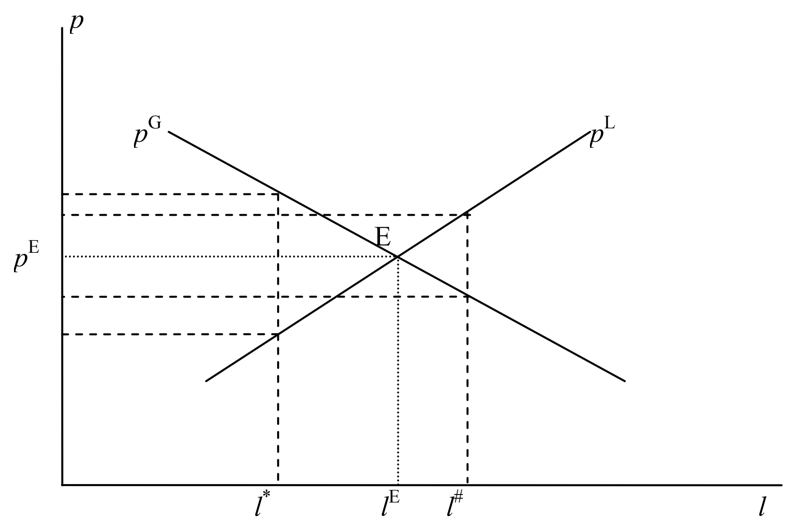

Fig. 3.1 Equilibrium of relative price and sectoral allocation of labor

$$(3.17) \qquad \frac{\mathrm{d}f^{N}}{\mathrm{d}[(1-l)\mathrm{L}]} = \gamma \frac{f^{N}}{l\mathrm{L}}$$

(3.17) has only one unknown, l. Let $G(l)$ be a function of l and

$$(3.18) \qquad G(l) = \gamma \frac{f^{N}}{l\mathrm{L}} - \frac{\mathrm{d}f^{N}}{\mathrm{d}[(1-l)\mathrm{L}]}$$

$G(l)$ is continuous and differentiable at least one time in its domain $(-\infty, \infty)$ since l is continuous in its range (0, 1) and f^{A} and f^{N} are continuous and differentiable at least two times.

Because $\lim_{l\to 0}f^{N}\to S$, $\lim_{l\to 0}lL\to 0$ and $\lim_{l\to 0}df^{N}/d[(1-l)L]\to W$, where S is a large finite and W a small one with L being a limited constant, then $\lim_{l\to 0}G(l)\to\infty$. In the opposite, $\lim_{l\to 1}G(l)\to -\infty$ since $\lim_{l\to 1}f^{N}\to 0$ and $\lim_{l\to 1}df^{N}/d[(1-l)L]\to\infty$. So there must exist some $l^{E}\in(0, 1)$, by the Intermediate Value Theorem, such that $G(l^{E})=0$, that is, (3.17) is satisfied. For a proof of uniqueness, we differentiate G with respect to l and get

$$\text{(3.19)}\qquad \frac{dG}{dl}=-\gamma L\frac{1}{lL}\frac{df^{N}}{d[(1-l)L]}-\gamma L\frac{1}{(lL)^{2}}f^{N}+L\frac{df^{N,2}}{d[(1-l)L]^{2}}<0$$

where all three terms on the right-hand side of the equation are negative since $f^{N}>0$, $(f^{N})'>0$ and $(f^{N})''<0$. Therefore, $G(l)$ is everywhere strictly decreasing and there exists a unique value $l^{E}\in(0, 1)$ that satisfies (3.17) and thus makes $p^{L}=p^{G}=p^{E}$ in Fig. 3.1. That means there is only a certain p^{E} corresponding to l^{E} that can clear both the markets simultaneously. In other words, at p^{E} the average product of farm labor $l^{E}L$ will be as high as the marginal product of nonfarm labor $(1-l^{E})L$, while farm output produced by $l^{E}L$ also equals at p^{E} the demand for it induced from the aggregate output brought about together by $l^{E}L$ and $(1-l^{E})L$ in both sectors.

The mechanisms for this simultaneous equilibrium can be highlighted with Fig. 3.2 below. The horizontal axis there represents the fixed total amount of labor of the economy, L. It is allocated between the farm and nonfarm sectors. The vertical dash line AB represents a certain labor allocation. Farm labor is measured from the left-hand origin toward the right and nonfarm labor from right to left. Correspondingly, Y^{A} starts from the left-hand origin and rises rightwards while Y^{N} begins from the right-hand origin and rises leftwards. Both graphs are drawn based on the given capital stocks θK and $(1-\theta)K$. Based on the assumption of lower agricultural productivity, a same quantity of nonfarm labor will produce more than that of farm labor does and the graph of Y^{N} curves up more steeply than that of Y^{A} in Fig. 3.2. The graph of Y^{A} is weighted by p in order to make it comparable with Y^{N}. Therefore, both the left- and right-hand vertical axes measure the sectoral and aggregate output in term of nonfarm product and both points A and B on Line AB are additive since $A=pY^{A}(lL)$ and $B=Y^{N}[(1-l)L]$. The straight lines combining the left-hand origin and points on pY^{A} help express the average value products of farm labor. Their angles with the horizontal axis, α, represent the average value product by

$$\text{tg}\alpha = p\frac{f^{\text{A}}}{l\text{L}} = pw^{\text{A}}$$

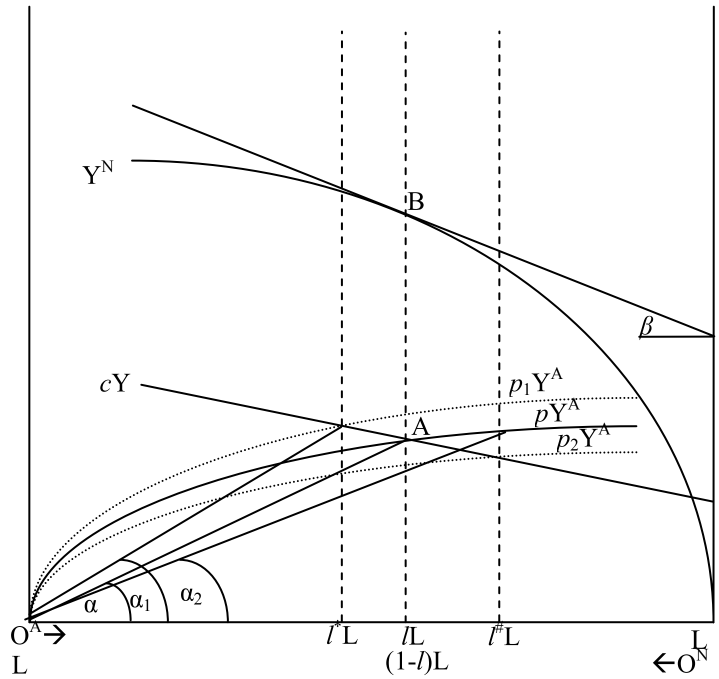

Fig. 3.2 Simultaneous equilibrium of labor and goods markets

From point Z on the right-hand vertical axis above, a line ZB is drawn upwards and left to be tangent at B on Y^{N}. Its intersection with the horizontal at Z forms an angle β and

$$\text{tg}\beta = \frac{\text{d}f^{\text{N}}}{\text{d}[(1-l)\text{L}]} = w^{\text{N}}$$

Therefore, the equilibrium condition of Equation (3.6) is converted geometrically into

(3.20) $\alpha = \beta$

for Fig. 3.2. The intersectoral labor market will equilibrate at Line AB when (3.20) is satisfied and L will be assigned to the farm and the nonfarm sectors, respectively. At this allocation, individuals have no incentive to migrate between the two sectors.

As Fig. 3.2 shows, fluctuations in *p* can be depicted by related ascending or descending movements of pY^A with Y^A being unchanged. But as soon as p fluctuates, α must change correspondingly and the original equilibrium on labor market breaks. We integrate demand function for farm product, cY, into Fig. 3.2 to investigate p. Note that cY is dependent on Y. Considering the graph of Y first. Because of $Y=pY^A+Y^N$, we get [17]

$$(3.21) \quad Y(l)=pY^A(lL) + Y^N[(1-l)L] \qquad \frac{dY(l)}{dl} < 0$$

according to the assumptions of full employment and lower farm productivity. Therefore, Y is minimal if all labor forces concentrate in farm production and will keep in increasing along with continuous decline in l. Hence, a graph of Y should start from a point E (>0) on the right-hand vertical axis and run up leftwards with its values being fixed by adding $pY^A(lL)$ and $Y^N[(1-l)L]$ at each allocation line in the domain of $1>l>0$. Referring to the graph of Y, we draw a curve for $pY^{A,D}=cY$ which will, as same as Y, go from E up to the left-hand side monotonously. But cY rises much more slowly than Y because $dc/dY<0$. For the sake of convenience and no loss of generality, we draw a line for cY in Fig. 3.2. The goods market will come to equilibrium at A in Fig. 3.2 where cY and pY^A intersect, meaning that demand for and supply of farm product match at p. However, the equilibrium depends on a certain labor allocation. It will not occur if the allocation lines lie right or left to Line AB. For example, there will be $cY(l^{\#}L)<pY^A(l^{\#}L)$ and p must fall if allocation line happens at $l^{\#}$ on the right of Line AB in Fig. 3.2. When it lies on the left of AB, p will rise because $cY(l^{*}L)>pY^A(l^{*}L)$. Both examples highlight that p has to change as soon as labor reallocates between the two sectors. In fact, Fig. 3.2 shows the simultaneous equilibrium for our labor and goods market model at A where three graphs of pY^A, cY and AB intersect and both equilibrium conditions of $\alpha=\beta$ and $pY^A=cY$ hold at the same time. Therefore, A in Fig. 3.2 represents the solution of Equation (3.17).

[17] Differentiating $Y(l)$ will give $dY(l)/dl=pL[dY^A/d(lL)]+Y^A(dp/dl)-L\{dY^N/d[(1-l)L]\}$. Because $dp^G/dl<0$ and $|dY^N/d[(1-l)L]|>p[dY^A/d(lL)]$, we get $dY(l)/dl < 0$.

IV. Equilibrium Migration of Labor

It is necessary to know about equilibrium changes in l, or equilibriums of m in order to understand intersectoral migration of agricultural labor because labor migration we discuss about is different from labor reallocation in the short-run: agricultural labor forces migrate in one direction in the long-run, although they can move in two directions in the short-run. The one-directional migration out of agriculture means l cannot remain stable or in equilibrium at any level it reaches for long. Researches on equilibriums of l are only the first step to the study of how l declines over time. Decline in l or migration of labor refers to at least two neighboring points of time between which it occurs. The economy at any point of time, t, is characterized by a set of the parameters $(\theta_t, K_t, L_t, c_t) \in (\theta, K, L, c)$, t=1, …, i, ... It is proved in the last section that there exists $(l_t, p_t) \in (l, p)$ which realizes equilibrium of the economy marked with $(\theta_t, K_t, L_t, c_t) \in (\theta, K, L, c)$ at t, t=1, …, i, ... Let t^* denote t+i and assume that the interval between t and t+i is well defined [18] and that $L_t=L_{t^*}$ to simplify our analysis. Labor migration between t and t^* is computed as $M_{t,t^*}=m_{t^*}L_t=(l_t-l_{t^*})L_t$. M_{t,t^*} could be seen as equilibrium migration since l_t and l_{t^*} are the equilibrium values at t and t^*, respectively. But this does not help understand labor migration any more because with it non-equilibrium migrations cannot be found and any m equilibrates. Therefore, we have to think of M and m from other angles. Considering an economy developing from t to t^*. What new the economy offers at t to itself at t^* is its savings at t, S_t, to be invested for new capital at t^*, ΔK_{t^*}. Suppose all savings will be invested and there are not depreciations in capital stock between t and t^*, that is, $S_t=I_t=\Delta K_{t^*}$. Thus, we have $(\theta_{t^*}, K_{t^*}, L_t, c_{t^*})=(\theta_{t^*}, K_t+\Delta K_{t^*}, L_t, c_{t^*})$ where K_t and ΔK_{t^*} are known after the time point t because S_t and I_t are determined at t. It is imaginable that there may be a set of the parameters $(\theta^E_{t^*}, K_t+\Delta K_{t^*}, L_t, c^E_{t^*}) \in (\theta_{t^*}, K_t+\Delta K_{t^*}, L_t, c_{t^*})$ at t^* which allows $(l^E_{t^*}, p^E_{t^*}) \in (l_{t^*}, p_{t^*})$ with $p^E_{t^*}=p_t$ to realize equilibrium of the economy at t^*,

[18] "Well-defined" means here on the one hand that between t and t^* there is a period consisting of many time points t+1, …, t+(i-1) where adjustments take place. On the other, the between-period must be short so that equilibrium is not deprived of its sense for the short-run analysis.

given (l_t, p_t) being the unique equilibrium set at t. Thus, the equilibrium migration, $M^E_{t,t*}$, could be defined as (l_t-l^E_{t*})L and the corresponding equilibrium $v_{t,t*}$ as (l_t-l^E_{t*}). [19]

We illustrate this definition with Fig. 4.1 where bold curves indicate the economy in equilibrium at t^*. Assume that at t, a part of both profits that nonfarm firms get and wages that farm and nonfarm labor forces earn will be saved for investments, while parts of nonfarm product are manufactured to satisfy investment demands. Investments will enhance capacity. With capital augmentations in both the sectors, the graphs of Y^A and Y^N will run steeper, meaning a certain labor force can produce more at t^*. The investments are assumed to be allocated "adequately" between the two sectors to, with related labor migrations, ensure concerted growths of Y^A and Y^N so that there are $c_{t*}Y_{t*}=p_{t*}Y^A_{t*}$, $p_{t*}w^A_{t*}=w^N_{t*}$ and $p_{t*}=p_t$ at t^*. Therefore, the economy develops with capital enhancements, output growth, stability of relative price, and wage increases which are reflected in $\alpha_{t*}>\alpha_t$ in Fig. 4.1. In this course, the speed at which cY and Y^A rise will be smaller than that for Y and much smaller than that for Y^N because of dc/dY<0. Hence, production extensions will be implemented mainly in the nonfarm sector. Nonfarm investments raise marginal productivity of nonfarm labor and lead to $w^N>pw^A$, attracting migration of more labor force out of farm sector, while investments in agriculture with resulting improvement in labor productivity in kind make the outmigration of farmers macroeconomically feasible. Thus, agricultural labor will transfer into nonfarm sector continually along with capital accumulations and the left-shift of the Allocation Line AB to A^*B^* gives the equilibrium migration of agricultural labor $M^E_{t,t*}=(l_t-l^E_{t*})L>0$ and equilibrium velocity $m^E_{t,t*}=(l_t-l^E_{t*})>0$.

[19] The definition can be imagined in Kaldor's pattern (1961) for the long run: A unit of farm product would be exchanged for unlimited nonfarm ones in the course of time if p would go still higher or all farm product could not be worth a unit nonfarm one if p would tend still lower. In the United States, p rose in the 19th century and fluctuated in the first half of the 20th century, but fell after the World War II. In general, p did not show clearly de- or increasing trends during the last two centuries of outmigration of agricultural labor in US (Dennis and Iscan, 2009).

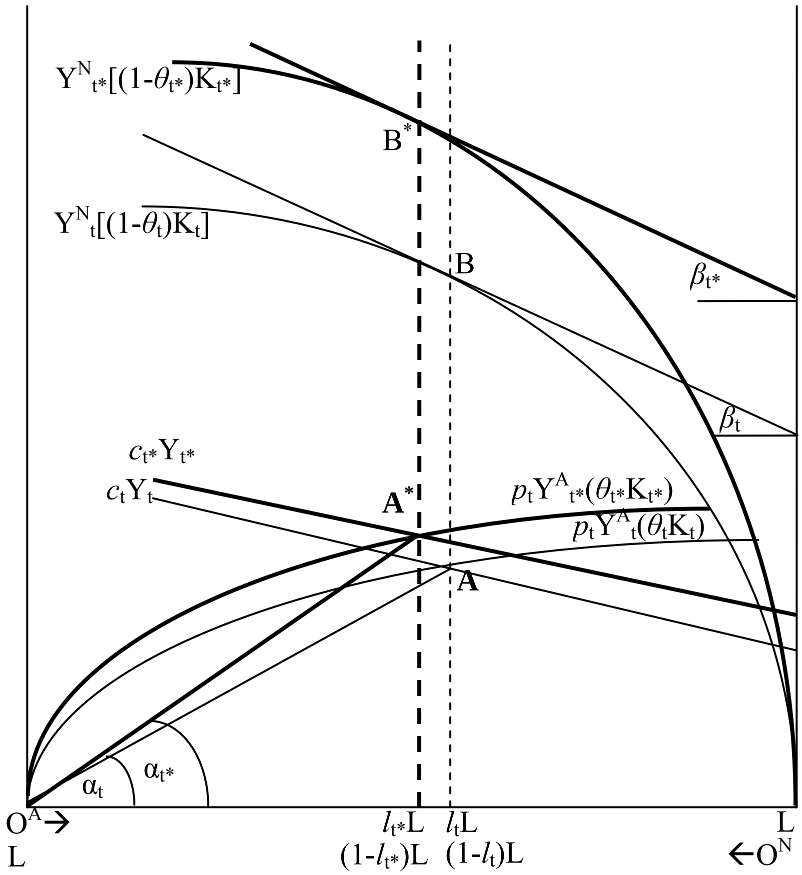

Fig. 4.1 Migration in comparative equilibrium [20]

The interactions of changes in K, L, θ, c, l and p as well as possible general equilibriums of M and m are left to further researches. The definitions of equilibrium M and m and its illustrations in Fig. 4.1 should be regarded as a working hypothesis in this paper. The essence of the hypothesis lies in that intersectoral reallocations of labor and capital after a one-time change in total capital may lead to a new equilibrium with a constant price. Here are some tentative explanations. According to assumptions made just above, K_t, ΔK_{t*} and thus K_{t*} are known after the time point t. What we need to know is values of θ_{t*} or the intersectoral allocations of K_{t*}. In order to get to this knowledge, however, we first need to know how ΔK_{t*} is allocated between farm and nonfarm sector at t^*. Let μ stand for ratio of investments in the farm sector to total

[20] Table 4.1 was published in Chinese in Hu (2008), but the explanations of migration equilibrium with the table were wrong. The same was also in the first version of this working paper issued in November, 2009.

investments, $\mu_{t*}=\Delta K^A_{t*}/\Delta K_{t*}$ and $\mu\in[0,1]$. The capital stock of the farm sector at t^*, K^A_{t*}, can be evaluated through two equations as follows

(4.1) $K^A_{t*}=\theta_{t*}(K_t+\Delta K_{t*})$

(4.2) $K^A_{t*}=\theta_t K_t+\mu_{t*}\Delta K_{t*}$

Combining the both and solving for θ_{t*}, we obtain

$$(4.3)\qquad \theta_{t*}=\frac{\theta_t K_t+\mu_{t*}\Delta K_{t*}}{K_t+\Delta K_{t*}}=\frac{\theta_t}{1+g_{K,t*}}+\frac{g_{K,t*}}{1+g_{K,t*}}\mu_{t*}$$

$$=\theta_{t*}(\mu_{t*})$$

and

(4.4) $d\theta_{t*}/d\mu_{t*}>0$

(4.5) $\theta_{t*}(\mu_{t*}=\theta_t)=\theta_t$

where $g_{K,t*}=\Delta K_{t*}/K_t$ is the growth rate of total capital stock between t and t^*, $g_{K,t*}>0$. Obviously, $\theta_{t*}(\mu_{t*})$ is a linear function. Since θ_t and $g_{K,t*}$ are known after the time point t, we will know about θ_{t*} as soon as μ_{t*} is determined.

We use Fig. 4.1 to see how to find $\mu^E_{t*}\in\mu_{t*}$ which leads to $\theta^E_{t*}\in\theta_{t*}$. Changes in K, μ, θ, l and c are reflected in shifts of graphs of Y^A, Y^N, AB and cY in Fig. 4.2. It is easy to see that p will increase if $\mu=0$, that is, if all investments are implemented in nonfarm sector and Y^N ascends to its highest position within the limit made by ΔK_{t*} while Y^A remains unchanged, which leads to too much demand for farm product. In the other direction p will decrease if $\mu=1$ when Y^A ascends to its highest position and Y^N descends back to Y^N_t, which causes too much supply in goods market. Starting from $\mu=0$, therefore, μ must rise in order to prevent p from increasing, thus a fraction of ΔK_{t*} is transferred into farm sector, which pushes the graph of Y^A and with it that of p_tY^A up while forcing the graph of Y^N down from its highest position with $\mu=0$. Continuing to raise μ as long as p tends to increase and turning to reduce μ if p begins to decrease. In raising and reducing μ continuously we shall find $\mu^E\in\mu\in[0, 1]$ that shifts the graphs of both p_tY^A and Y^N to such the positions where, with corresponding movements of the Line AB, $p_tY^A_{t*}=c_{t*}(p_tY^A_{t*}+Y^N_{t*})$ and $p_t[Y^A_{t*}/(l_{t*}L)]=dY^N_{t*}/d[(1-l_{t*})L]$ simultaneously, that is, we shall find the equilibrium position A^* in Fig. 4.2 and $\theta^E_{t*}(\mu^E_{t*})$ and $(l^E_{t*}, p^E_{t*}=p_t)\in(l_{t*}, p_{t*})$ for the economy with $(\theta^E_{t*}, K_t+\Delta K_{t*}, L_t, c_{t*})\in(\theta_{t*}, K_t+\Delta K_{t*}, L_t, c_{t*})$ at t^*.

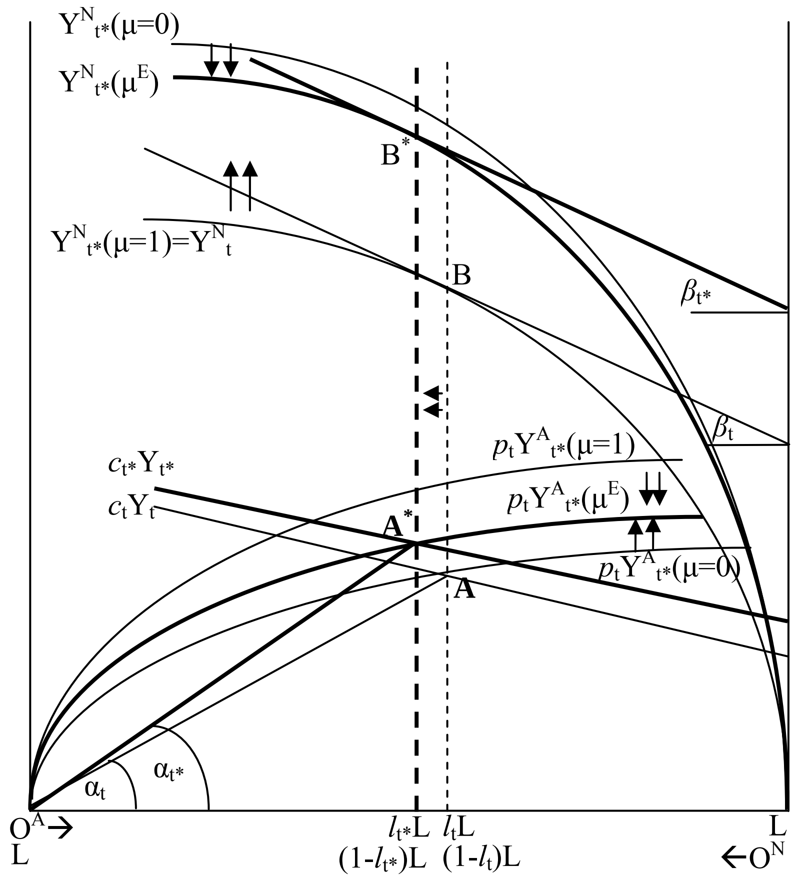

Fig. 4.2 Existence of equilibrium migration

The intuitions illustrated in Fig.4.2 can be partly proved here. Given p^E_t being equilibrium value at t evaluated from Equation (3.15) after l_t^E is known through solving (3.17), the total differential of p_t^E with respect to K and θ is

$$dp_t^E=\gamma\frac{1}{f^A(\theta K,lL)}\frac{df^N[(1-\theta)K,(1-l)L]}{d[(1-\theta)K]}[(1-\theta)dK-Kd\theta]$$

$$-\gamma f^N\frac{1}{[f^A(\theta K,lL)]^2}\frac{df^A(\theta K,lL)}{d(\theta K)}(Kd\theta+\theta dK)$$

Let $dp^E_t=0$ and rearrange it to

(4.6) $$\frac{d\theta}{dK} = \frac{1}{R}\{(1\text{-}\theta) f^{A} \frac{df^{N}}{d[(1-\theta)K]} \text{-} \theta f^{N} \frac{df^{A}}{d(\theta K)}\}$$

where

$$R = K f^{A} \frac{df^{N}}{d[(1-\theta)K]} + K f^{N} \frac{df^{A}}{d(\theta K)} \qquad R \neq 0,\ R > 0.$$

$d\theta/dK$ exists since $R \neq 0$. It implies that there must, to every change in K, be some corresponding changes in θ that make p stable as K changes. The direction of changes in θ depends on the numerator of the right-hand side of (4.6) given $R>0$. The numerator can be rewritten as

(4.7) $$f^{A}\{(1\text{-}\theta) \frac{df^{N}}{d[(1-\theta)K]} \frac{K}{K} \frac{f^{N}}{f^{N}} \text{-} \theta f^{N} \frac{1}{f^{A}} \frac{df^{A}}{d(\theta K)} \frac{K}{K}\},$$

$$= \frac{f^{A} f^{N}}{K} \{(1\text{-}\theta) K \frac{df^{N}}{d[(1-\theta)K]} \frac{1}{f^{N}} \text{-} \theta K \frac{df^{A}}{d(\theta K)} \frac{1}{f^{A}}\}$$

$$= \frac{f^{A} f^{N}}{K} (e_{K}^{N} - e_{K}^{A})$$

where $e_{K}^{N} \in (0,\ 1)$ and $e_{K}^{A} \in (0,\ 1)$ represent output elasticities of capital of the two sectors, respectively. Thus, the range of values of $d\theta/dK$ is given as follows:

(4.8) $$\frac{d\theta}{dK} \begin{cases} > 0 & e_{K}^{N} > e_{K}^{A} \\ = 0 & e_{K}^{N} = e_{K}^{A} \\ < 0 & e_{K}^{N} < e_{K}^{A} \end{cases}$$

That is, θ will rise if one percentage growth of capital can cause more percentage increments of output in nonfarm than in farm sector in order to keep p stable when total capital increases, and it will fall in the opposite case. Only when both elasticities are equal does θ not change along with growth of capital. Economic meanings of (4.8) may be understood, e.g, that if $e_{K}^{N} > e_{K}^{A}$ and θ does not rise, nonfarm output and then aggregate one will grow more quickly than farm output after an increase in K. In the absence of decreasing changes in c demand for farm product will surpass its supply, which moves p higher. In order to keep p constant, θ has to rise, pointing that

$\mu_{t*}>\theta_t$, that is, investments should be allocated proportionally more to farm sector. In the opposite case of $e_K^N < e_K^A$ relatively more investments should be made in nonfarm sector to achieve the balance of demand and supply in the good market. Therefore, θ seems to be a powerful mechanism to help make even the path of decline in l along with capital accumulations because a constant p during several consecutive periods can lead to smaller $|a|$ or reduce undesired changes in m caused by adjustments absorbing too quick de- or increases of the relative price.

V. Migrations and Business Cycles: A Discussion

What triggers the short-run fluctuations on labor and/or goods market are external and internal shocks. From the hypothesis explained above, one of the possible sources of shocks may be unexpected and large changes in each of the four parameters (θ, K, L, c). For example, $\mu \neq \mu^E$ brings about $\theta \neq \theta^E$ which allocates capital stock between the farm and nonfarm sectors inadequately and leads to too high or too low p and with it economic fluctuations. Figure 3.2 may be a useful tool for the analysis of these fluctuations and resulting adjustments. $\mu<\mu^E$ means, e.g., too much investments in nonfarm sector, which will drive up the graph of Y^N, widen β to surpass α in Figure 3.2. Hence farm labor migrates out to nonfarm activity for more income. The economy booms. But after a while p will rise because of both increased cY as a result of higher Y and stagnated Y^A caused by too less investments in agriculture combined with massive out-migration of farm labor. Clearly rising p pushes w^N up since nonfarm workers appraise their wages by the means of quantity of farm product they can exchange for. The economy may go into the phase of inflation measured by rapid depreciations in the numeraire against farm product. As p and w^N increase strongly, nonfarm production will be less profitable and some firms could go bankrupt, which leads the economy to slowdown. Then p and w^N will turn to fall because of decreasing demands for farm product and labor. Some migrated labor is even forced to go back to agriculture. At lower p and w, the economy will invest again, that is, $\mu<\mu^E$, more in nonfarm sector and begin a new round of its business cycles.

To substantiate the concrete economic meanings and derive implications for economic policy, we consider macroeconomic performance in China in the last years. Because of lack in data our discussions are very limited. China began to publish data on shares and growth rates of investments in agriculture and nonagriculture in 2007, which are, with sectoral shares in GDP, rearranged in Table I. It shows that agricultural investment share was much less than its output share and even tended diminishing until 2008 when investment in agriculture grew sharply at 50%. It may suggest $\mu < \mu^E$ in China at least in 2006 and 2007. China's economy boomed in these years as depicted in Table II when labor transferred from farm to nonfarm sector in large scale and urban unemployment even decreases in 2007. At the same time, Table II points out again the comparative importance of migration to unemployment for macroeconomic performance in China. As predicted by our model, food price went up to 12.3% abruptly in 2007 in comparison with 2.3% in 2006 and brought CPI to be tripled as shown in Table III. It is said that 80 percent of growth of CPI was contributed by growth of food price in 2007 and 2008 (NBSC, 2008a; 2009b). That means strong increases in relative price of food to other commodities included in CPI. The economy had to adjust and slower its growth. Out-migration of agricultural labor became smaller despite large investments in nonfarm sectors, even return migration happened, as mentioned at the beginning of this paper.

Table 5.1 Sectoral Shares in GDP and Investment in China, 2005-2008

Year	Share in GDP			Share in Investment in Fixed Assets			Growth Rate of Investment		
	Total	Agri-culture	Nonagri-culture	Total	Agri-culture	Nonagri-culture	Total	Agri-culture	Nonagr-iculture
2005	100	12.2	87.8	100	2.62	97.38			
2006	100	11.3	88.7	100	2.50	97.50	23.9	18.3	24.1
2007	100	11.1	88.9	100	2.48	97.52	24.8	23.8	24.9
2008	100	11.3	88.7	100	2.93	97.07	25.9	48.8	25.3

Sources: Ratio of GDP: NBSC, 2009a, Table 2-2. Share and growth rate of investment: NBSC, 2007, Table 6-1; NBSC, 2008b, Table 5-1; NBSC, 2009a, Table 5-1.

Notes: Data on both shares in GDP and on growth rate of investment are calculated without removing the factor of price.

Table 5.2 Growth Rate of GDP and Labor Market in China, 2005-2008

Year	g	l	m	M	U	ΔU	u	u*	ΔU/M
	%	%	%	million	Million	million	%	%	%
2005	10.4	44.31	2.08	15.95	8.39	0.12	1.09	0.02	0.75
2006	11.6	42.15	2.16	16.67	8.47	0.08	1.10	0.01	0.48
2007	13.0	40.41	1.75	13.59	8.30	-0.17	1.07	-0.02	-1.25
2008	9.0	39.12	1.29	10.11	8.86	0.56	1.13	0.07	5.54

Sources: as for Figure 2.1 and 2.11. u*=ΔU/L.

Table 5.3 Engel's Coefficients and Price Indexes in China, 2005-2008

Year	Per Capita Annual Disposable Income of Urban Households		Per Capita Annual Net Income of Rural Households		Engel's Coefficient of Urban Households	Engel's Coefficient of Rural Households	CPI	Food Price Index
	Year of 1978=100	Growth rate	Year of 1978=100	Growth rate				
		%		%	%	%	%	%
2005	607.4	9.60	624.5	6.21	36.7	45.5	1.8	2.9
2006	670.7	10.42	670.7	7.40	35.8	43.0	1.5	2.3
2007	752.5	12.20	734.4	9.50	36.3	43.1	4.8	12.3
2008	815.7	8.40	793.2	8.00	37.9	43.7	5.9	14.3

Sources: Households income and Engel's coefficients: NBSC, 2009a, Table 9-2. CPI and food price: NBSC, 2009a, Table 8-6.

We use Figure 5.1 to illustrate the adjustments of Chinese economy. Starting from a demand shock which suddenly raises demand sharply and pushes c up to $c' > c$.[21] In Figure 5.1 $c\mathrm{Y}$ moves up to $c'\mathrm{Y} > p\mathrm{Y}^{\mathrm{A}}$ on the allocation line AB and p rises accordingly. If the adjustments take place only and wholly on goods market, p will rise to p', pulling $p\mathrm{Y}^{\mathrm{A}}$ up to $p'\mathrm{Y}^{\mathrm{A}}$ with unchanged Y^{A}. $p'\mathrm{Y}^{\mathrm{A}}$ intersects on both $c\mathrm{Y}'$ and AB at A' where demand meets supply on goods market again. $p'\mathrm{Y}^{\mathrm{A}}$ forms a curve of $\mathrm{O}^{\mathrm{A}}\mathrm{AA'A}^{\#}$ and kicks twice at A and A', representing a one-time push by p rising to p'.

[21] China's Engle coefficient rose in 2007 and 2008 although the average households increased their real incomes clearly in both years as shown in Table 5.3. But the rise may not be a puzzle because growth rates of households' real income were lower than that of food price, that is, real income will decrease if measured by number of food it can purchase.

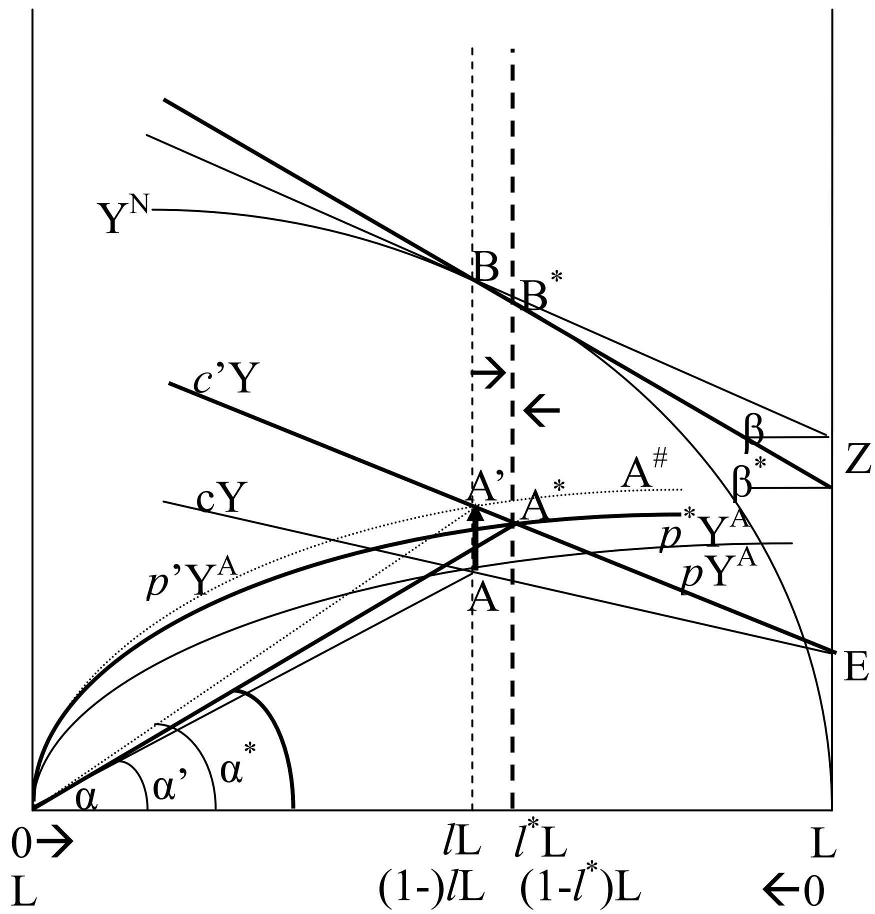

Figure 5.1 Fluctuation in Migration and Return to Equilibrium

However, the balance on goods market at A' is not stable because of α'>α=*β* following the leftward rotations of O^AA to O^AA'. Equilibrium on labor market also breaks. A part of nonfarm labor will transfer to farm sector for higher earnings. Even if it is realized partly, Y^A will rise, which brings goods market out of balance again since *p* must change further to respond to increases in supply. But changes in *p* have effects on sectoral wage comparisons and labor market gets into fluctuations once more. The interactions of goods and labor market make clear that no single market can absorb shocks alone. Any shocks which first destroy equilibrium on a market must be transmitted to another market through changes in relative price and wage rates. In an economy with flexible price and wage rates as well as mobile labor forces, a one-time demand shock will launch adjustments in both the markets simultaneously and the economy may come to a new equilibrium at A^* for both the markets again. The new equilibrium price, p^*, is higher than p, which is a footprint of an internally accumulated or an external shock in the immediate past. As to other macroeconomic variables, p^*w^{A*}, w^{N*}, Y^{A*} and l^* will surpass their last equilibrium levels, while Y^{N*} and profits that nonfarm firms earn fall below the last levels. Y^*, the aggregate income computed in terms of nonfarm product, will exceed Y, but merely due to the increases in p. According to Equation (3.21), however, the deflated or real $Y^{*R}<Y$ because, as the result of the adjustments, more labor is employed in lower productive farm sector and less in the higher productive one. On the whole, the economy experiences an inflation and a downturn, with return migration of agricultural labor measured by $-M=-(l-l^*)L=-mL$. According to the definition of equilibrium migration in the last section, it is not the equilibrium one because of changes in p.[22]

One of the nonfarm firms' responses may be to manage to keep their workforce in production in the face of rising p. Firms that produce to order respond in this manner particularly because they are unable to adjust production, often unable to renegotiate on the selling prices listed in the orders as well during the period from acceptance of orders to shipment of deliveries. If the firms are not capable to enhance capital or improve techniques, they even cannot adjust labor forces they employ. After p rises suddenly, pw^A goes up. Firms have to raise w^N to maintain their employment, which necessarily leads to fall in profits. From the macroeconomic points of view, that the nonfarm firms are difficult to reduce employment as a response to increases in p implies the adjustments to the shock may take place mainly on goods market. Therefore, the extent to which p rises will be much bigger than that if labor market adjusts simultaneously. With bigger increases in p, w^N must go up more for employees to maintain the purchase power of their wage in term of farm product and for employers to prevent labor forces from leaving. The strong rises in p, pw^A and w^N will be translated into overheating in both markets: supply of farm product is short of demand on the one hand, supply of labor is short of demand on the other. Overheating of the goods market is transmitted to that of the labor market. More labor is demanded in

[22] Technically speaking, migration in Figure 5.1 is triggered by a change in c, one of the parameters we do not deal with detailedly. It is clear from Equation (3.15) and (3.17) that p and l move in the same direction of changes in c if capital and its sectoral allocation remain unchanged.

agriculture to produce more farm products and in nonfarm sector to ease the pressure of rises in w^N. But there is not labor available to be employed either in agriculture or nonfarm firms. A developing country usually characteristic of redundant labor force saved in agriculture suddenly finds itself being in a dilemma of labor shortage. It seems unavoidable that some firms are forced to reduce production because of unexpected high labor costs. The production reduction by these firms may have effects predicted by the domino theory. Many firms have to follow and some even go bankrupt. A turn comes suddenly as the same as the shock begins. At one blow, labor cannot find jobs any more. Wage rates cannot go up any more. Prices begin to fall. Many migrated workers are laid off and have to go back to their original villages. A slowdown of economic activity which is needed to absorb the rise in p caused by a shock may turn to be a serious crisis, which will call the policy maker for actions.

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