Dropping out of Floating Children in China: Explanation and Evidence*

Wenbin Wang  
(School of Economics and Management, Inner Mongolia University)  
Heng Yin  
(School of Economics and Business Administration, Beijing Normal University)

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Abstract: We propose a population floating-education model, investigating the reason and determinants of dropping out of floating children in China. The children education choice of floating households reflects the balancing of difference of education level between the flow-out district and flow-in one and the probability of obtaining education in the flow-in district. We find that the root cause of dropping out of floating children is the disparity of the price and quality of education and the limited capacity of urban school. The lower the price of education in the flow-in district is, or the higher the education quality in the flow-in district is, or the higher the price of education in the flow-out district is, or the lower the education quality in the flow-out district is, or the older the floating child is, or the higher the left-behind cost is, the higher the dropout rate of floating children will be. Based on the data sets from the 2000 census and the 2005 1% population survey, we find that the model is consistent with the empirical evidence. This framework can also explain why the governments of flow-in district have no incentive to implement the “Two Major Responsible Subjects” policy, and have a tendency to raise the threshold of entering public schools for floating children.

Key words: population floating-education model; dropping out of floating children; “Two Major Responsible Subjects” policy; China

JEL Classification: H52, I28, J61, R23
I. Introduction

With economic transition and development in China, the internal migrants have grown rapidly. Meanwhile, the “floating population” (liudong renkou)\(^1\) who has not been able to obtain the hukou (household registration) of “flow-in” district (liuru di) has become the majority of migrants (Yang, 2003). As time goes on, the floating population is inclined to float with their whole family, and to settle down permanently in the flow-in district. According to the data of the 2000 census and the 2005 1% population survey, there were 14.10 million floating children\(^2\) (liudong ertong, defined as the floating population who is not older than 14 years old) in 2000, and the figure rose to 18.34 million in 2005. During the corresponding time period, the number of school-aged floating children (defined as the floating children between 6 to 14 years old) rose from 8.78 million to 11.26 million (Duan and Liang, 2004; Duan and Yang, 2008).

Compared with local children, floating children have suffered a number of disadvantages in education (Shi, 2005), and China's hukou system (Tao, 2009) has greatly added difficulties to this problem. According to national regulations in the late 1990s, only those floating children without guardianship in the registered districts could study in the flow-in districts, and schools in the flow-in districts could charge special fees\(^3\). In practice, it is common that public schools in the flow-in districts charge the floating children much more than the local students in the form of “temporary schooling fee” (jiedu fei), “sponsorship fee” (zanzhu fei) and other fees (Yu et al., 1997; Zhao, 2000). Therefore, a large number of floating children have no choice but to enroll in “floating children schools” (liudong ertong xuexiao)\(^4\) which are cheap but with poor condition (Zhao, 2000; Lu and Zhang, 2004; Han, 2004). Meanwhile, there are a large number of floating children who drop out of school altogether (Li and Wang, 1998; Lu and Zhang, 2004). In the view

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\(^1\) In reference, “floating population” is also known as “informal migrants”, and has been early discriminatory called “vag (blindly floating population, mangliu)”.

\(^2\) In all floating children, the “migrant children of the peasant-worker” (nongmingong suiqian zinu) have attracted special attentions. These children, defined as the floating children who hold agricultural hukou, accounts for about 3/4 of floating children (Duan and Liang, 2004; Duan and Yang, 2008).


\(^4\) Floating children schools are also known as dagong zidi xuexiao. Many of them are founded by floating population, and the majority cannot be authorized by the governments in a long time. The condition of these schools are generally poor, but the lower charges and flexible system of operation give them existence, so they flourish in floating population gathering zone of large cities. (Zhao, 2000; Lu and Zhang, 2004; Han, 2004; Woronov, 2009)
of this fact, the State Council (SC) promulgated “Decisions on the Reform and Development of Elementary Education” (SC, 2001) on May 29, 2001, stipulating that the government and public schools in the flow-in districts are responsible for the floating children’s compulsory education. Since then, the Government has introduced several policies in order to reduce the fees of floating children to study in public schools. However, the local governments of flow-in districts lack the motivation to carry out these policies. Only half of the cities explicitly stipulated that public schools could not charge floating children of temporary schooling fee in 2007, four years after the policies were released (Central Institute of Educational Sciences Research Group, 2008). Meanwhile, most schools of the cities have strict entrance requirements which increase the difficulties of enrolling floating children in public schools (Liu, 2009). Take Beijing for example, floating children must show their Temporary Residence Permit (zanzhuzheng), proof of residence, proof of parents’ employment in Beijing, proof of no guardianship in the registered districts, Household Register (hukou bu), and proof of previous school if they want to attend public schools (Beijing Municipal Government Office, 2004). At present, the issue of floating children’s education is far from been resolved.

Most research on migrant children’s education abroad has focused on social capital (Coleman, 1988; Hagan et al., 1996). The problem of floating children’s education has been a hot interdisciplinary topic for more than ten years, involving education, demography, sociology, management, and economics. However, the existing research is mainly case work and descriptive analysis, while systematic theoretical and empirical analysis is very scarce. A few in-depth studies based on micro-data have found some interesting facts. For example, based on the 1995 1% population survey data of Guangdong Province, Liang and Chen (2007) found that the enrollment rate of floating children between 6-15 years old was below local children, and also lower than children in the flow-out districts (liuchu di) after controlling for a variety of personal and family characteristics. Other things being equal, the longer the parents’ flow time, the higher the enrollment rate of their children in local schools. Using data of census of nonnatives (wailai

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3 The regulation, “The Opinion on Further Improving the Compulsory Education for Children of Peasant-Worker Floating in Cities” (GOSC, 2003), asked for even charges for compulsory education between floating children and local students, canceled the legitimacy of “temporary schooling fee” and “sponsorship fee”. The regulation, “Circular on the Abolition of Tuition and Miscellaneous fees for Students in Compulsory Education in Cities” (SC, 2008), permitted migrant children of the peasant-worker who satisfied the government rules to study in public schools, with no tuition, miscellaneous fees and temporary schooling fee.
renkou) in Beijing in 1997, Guo (2002) found that the enrollment rate of floating children between 6-14 years old was 88%; after controlling for parents’ socio-demographic characteristics, older boys were more likely to be enrolled into public schools; if the parents’ education level was higher, if they stayed in Beijing longer and held non-agricultural hukou, their children were more likely to be enrolled in public schools. Using survey data of floating children of nine cities in 2002, Lu (2007) found that the enrollment rate of floating children between 7-18 years old was 91.2%, and 15.2% of them study in “floating children schools”; other things being equal, the enrollment rate of the floating children who was more younger, had more flowing time, lived with their parents, the parents moving many times, had better economic conditions, was higher; those floating children in the coastal areas, or cities with high level of economic development and larger proportion of floating population had much lower enrollment rates.

Until now, there is no any formal model that examines dropping out of floating children in China at home and abroad. Inspired by Todaro (1969) and Harris and Todaro (1970), this paper develops an economic model to analyze the families’ floating-education decision comprehensively and the reasons for the high dropout rates of floating children. The floating families’ decision to enroll the children reflects the trade-off between education premium of flow-in districts and the possibility of being enrolled. Cities provide more attractive education price–quality combination, but its capacity is limited; to get better education services, floating families are willing to bear the risk of their children dropping out. This is the root cause of floating children’s dropout. The theoretical model points out that the price and quality of education in the flow-in districts and flow-out districts, the age of floating children, and the left-behind (liushou) cost are the most important factors influencing the dropout rate of floating children. The paper uses data from the 2000 census and the 2005 1% population survey, including 28949 (2000) and 56239 (2005) school-aged children, 2888 (2000) and 7408 (2005) floating children in cities, to test the theoretical hypotheses.

The empirical result is consistent with our theoretical hypotheses. The dropout rate of floating children is far higher than that of the local children. The lower the price of education in the flow-in district is, or the higher the education quality in the flow-in district is, or the higher the price of

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6 Recently, some researchers began to focus on the academic performance of floating children (Zhou and Wu, 2008; Wu et al., 2010)
education in the flow-out district is, or the lower the education quality in the flow-out district is, or the older the floating child is, or the higher the left-behind cost is, the higher the dropout rate of floating children will be.

The paper proposes a theoretical model in the second part, the empirical analysis is in the third part, and the fourth part concludes.

II. A Population Floating-Education Model

A. Economic Environment

Potential floating family generally consists of parents and child (or children). Parents are at labor age, with children at school age. In this section, we will first clarify the families’ action objective, and the structure of labor and education market.

(1) Utility function of floating family

Utility function of potential floating family with neutral risk is as followed:

\[ V = ju(p,q) + [1 - j]w_c + w - c \]  

(1)

In the formula above, \( j \) is the probability of children from floating families enrolled in schools. \( u(p,q) \) presents utility of family from obtaining the education of their children, in which \( p \) refers to the price of education, including school fees and the cost of receiving admission qualification (Temporary Residence Permit, proof of residence, proof of parents’ employment, and so on), \( q \) is the quality of education; and \( p_O \) and \( q_O \) are for schools in flow-out districts, \( p_I \) and \( q_I \) for schools in flow-in districts. \( w_c \) expresses expected income of engaging in work as child labor. \( w \) presents income of parents, as \( w_O \) and \( w_I \) respectively for parents in flow-out and flow-in districts. \( c \) is the relevant cost, including \( c_f \) (floating cost), which is directly caused by the floating, such as the

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7 \( p_B, q_B \) refers to educational charge and education quality in the flow-in district, which are quite different from the charge and quality of local students with household registration. Mostly, all of schools in flow-in district will clarify the students without household registration into special group. Compared with local students, they have to pay much more fees: in 2000, the educational fees of floating children in nine cities are at average more 856.4 yuan than those of local students (Duan and Liang, 2005)

8 Suppose that the cost of parent-floating is equal to the cost of family-floating, as \( c_f \).
traffic cost, \( c_2 \) (left-behind cost), which results from the dissatisfaction of parent-child separation because of floating-out of parents and left-behind of children, and \( c_3 \) (reverse left-behind cost), which results from the dissatisfaction of parent-child separation because of floating-out of children and left-behind of parents.

Moreover,

\[
u(p, q) > 0
\]

(2)

\[
\frac{\partial u(p, q)}{\partial p} < 0
\]

(3)

\[
\frac{\partial u(p, q)}{\partial q} > 0
\]

(4)

\[c_1, c_2, c_3 \geq 0\]

(5)

(2) The structure of labor market

The sum \( N \) of labors in flow-out districts and floating labors in flow-in districts is exogenously given. For potential floating labors, labor markets in both flow-out and flow-in districts are competitive, so there is no unemployment. Additionally, there is no reverse floating from flow-in districts to flow-out districts. Therefore, we have the following identity:

\[
N = N_1 + N_2
\]

(6)

In the identity, \( N_1 \) is the quantity of labors employed in flow-out districts; \( N_2 \) is the quantity of labors employed in the flow-in district.

\( D_a(w_a) \) and \( D_b(w_b) \) are the demand for potential floating labor in flow-out and flow-in districts respectively. It’s worth noting that \( D_b(w_b) \) refers to demand for floating labor in flow-in districts when other production factors including local labor is given. Both \( D_a(w_a) \) and \( D_b(w_b) \) are downward-sloping:

\[
D_a(w_a) = N_1
\]

(7)

\[
D_b(w_b) = N_2
\]

(8)

\[
D_a'(w_a) < 0
\]

(9)

\[
D_b'(w_b) < 0
\]

(10)
(3) The structure of education market

The number of school-aged children in floating family \( M \) is directly proportional to the amount of floating labors:

\[
M = lN_2
\]  
\( l > 0 \)  

(11)  

(12)

\( M_A \) and \( M_B \) respectively refer to educational supply (measured by enrollment capacity) provided for children from potential floating families. \( M_A \) and \( M_B \) are determined by educational authorities in flow-out and flow-in districts respectively. We assume that \( M_A \) is big enough, so that all floating families can enroll their children in schools of flow-out districts if they want\(^9\). So we have the following identity:

\[
M = M_1 + M_2 + M_0
\]  

(13)

In the identity, \( M \) is total number of school-aged children in floating families; \( M_1 \) and \( M_2 \) are the number of floating children enrolled in the schools of flow-out and flow-in districts respectively; \( M_0 \) is the number of floating children dropping out in the flow-in districts.

\( j \), the probability of floating children enrolled in schools, equals 1 in flow-out districts, while \( j \) equals \( j(M_0, M_2) \) in flow-in districts. The opportunity of enrolled in schools in flow-in districts obeys the uniform probability distribution for children from floating families, so the form of function \( j(M_0, M_2) \) is as follows:

\[
j(M_0, M_2) = \frac{M_2}{M_0 + M_2}
\]  

(14)

We assume that children from floating families who fail to acquiring admission in their flow-in district can’t get back into their original school in the same term. Namely, the cost of getting back into the original school is higher than the benefits. Therefore, they can only choose schools in the next term.

\( p_A, q_A \) and \( p_B, q_B \) are determined by the education authorities of the flow-in and flow-out district respectively, and we assume they follow

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\(^9\) The original supply of education in flow-out districts is designed for all school-aged children holding \( hukou \) of flow-out districts, therefore, such assumption is reasonable.
This means that the education provided by the flow-in district is better than that of the flow-out district for floating families, so

\[ M_2 = M_0 \]  

(16)

Among the floating children, child-labor problem is common\(^\text{10}\). Take the possibility to work of school-aged floating children into consideration. We assume that the market of child labor and the market of floating adult labor are separable. Let the expectation income of child labor be \( w_C(t) \), where \( t \) represents her age. Assuming that floating children go to work only when they drop out of school, namely

\[ u(p_b, q_b) > u(p_d, q_d) - c_2 > w_C(t) > 0 \]  

(17)

Assuming that the older the child-labor is, the higher her expected income is:

\[ w_C'(t) > 0 \]  

(18)

**B. Equilibrium of the Model\(^\text{11}\)**

Potential floating families stay in one of four states: both of parents and children don’t float; parents don’t float while children float to flow-in district to study; parents float to flow-in district to work while children stay in the flow-out district to study; both of parents and children float to flow-in district. The utility of the four states is as follows:

\[ V_1 = u(p_d, q_d) + w_d \]  

(19)

\[ V_2 = j(M_0, M_2)u(p_b, q_b) + \left[ 1 - j(M_0, M_2) \right] w_C(t) + w_d - c_3 \]  

(20)

\[ V_3 = u(p_d, q_d) + w_b - c_1 - c_2 \]  

(21)

\[ V_4 = j(M_0, M_2)u(p_b, q_b) + \left[ 1 - j(M_0, M_2) \right] w_C(t) + w_b - c_1 \]  

(22)

According to \( V_1 = V_2 \) and \( V_3 = V_4 \), we can get the equilibrium condition of labor market and education market:

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\(^{10}\) In 2002, over 60% of the 12-14 years old dropouts in 9 cities had been employed (Duan and Liang, 2005).

\(^{11}\) In this paper, equilibrium means that given other families’ behavior, all the families in the model have no motivations to change their own behavior.
According to (24) and (20), we can get
\[ V_2 = u(p_a, q_a) + w_a - c_a - c_3 \] (25)

Comparing to (19), we find out \( V_1 > V_2 \). This is agreement with the fact that it hardly happens that parents don’t float while children float to flow-in district to study.

According to (23) and (24), the decision of potential floating family on labor market and education market is detached, so we can discuss the equilibrium of labor market and education market respectively. The reason of this convenience is the assumption of utility function being algebraic sum. The utility function is quasi-linear so that the wealth does no effects on the optimal choices of family if the wealth is not too little.

Firstly, we analyze the equilibrium of labor market\(^{12}\). Labor market satisfies equations (6), (7), (8), and (23), as follows:

\[ N = N_1 + N_2 \] (6)
\[ D_A(w_a) = N_1 \] (7)
\[ D_B(w_b) = N_2 \] (8)
\[ w_a + c_1 + c_2 = w_b \] (23)

This four equations determine the equilibrium value of the four endogenous variables: \( N_1, N_2, w_A, \) and \( w_B \). Figure 1 describes the equilibrium of labor market.

\(^{12}\) In the model, it can exclude the possibility of unemployment in cities for migrants through the hypothesis that the market of floating labor forces in floating-in is sufficient competent, which is quite different with Harris-Todaro Model. In the Harris- Todaro model, urban wage is higher than the pay level of clear labor market, which leads to unemployment. If this model includes the unemployment of urban floating labor, the main comparison of static of the resulting model is the same as baseline model. Moreover, compared to urban local labor, the unemployment of floating labor is lower; In 2000, the unemployment rate of urban local labor is 9.1%, the unemployment rate of urban to urban area is 7.9%, while the unemployment rate of rural to urban area is only 3.6%.(Wang , 2004). Therefore, this article uses the baseline model assumptions.
In figure 1, L_A and L_B represent the inverse labor demand curve in flow-in and flow-out district respectively. At the intersection point of L_A and L_B, E, Labor market reached equilibrium. Actually, both N_1 and N_2 don’t equal to 0, this rules out the possibility that L_A and L_B intersect above F or G.

Education market satisfies equations (11), (13), (14), (16), (24), as follows:

\[
M = lN_2 
\]

\[
M = M_1 + M_2 + M_0 
\]

\[
j(M_0, M_2) = \frac{M_2}{M_0 + M_2} 
\]

\[
M_2 = M_B 
\]

\[
u(p_t, q_t) = j(M_0, M_2)u(p_g, q_b) + [1 - j(M_0, M_2)]w_c(t) + c_2 
\]

This five equations determine the equilibrium value of the five endogenous variables M, M_1, M_2, M_0, j. Substituting (14) and (16) into (24), we can get the explicit value of M_0, the number of floating children dropouts:

\[
M_0 = \frac{u(p_g, q_b) - u(p_g, q_b) + c_2}{u(p_g, q_b) - c_2 - w_c(t)}M_B
\]

According to (15), (17), the numerator and denominator of the right hand side fraction of (26) is positive, therefore, M_0 must also be positive. We express it as follows:

**Proposition 1**: Some floating children are dropouts.
Figure 2 describes the equilibrium of education market.

In Figure 2, the ways of using public educational resources in flow-out places are inefficient. If it can reduce the educational scale of floating-out, so that it can save these funds to lower school admission charge and improve quality of education. On the condition that no increase of public educational funds, it can decrease the amount of dropout students in floating-out, with higher quality of educational services.

In figure 2, S_A and S_B respectively represent the education supply curve provided by flow-out and flow-in district. S_A locates in the right of S_B, which means that the total admissible capacity to absorb floating children in schools of flow-out and flow-in district is larger than the number of school-aged floating children. Curve hh measures the value of education in flow-in district and child-labor income for floating family corresponding to different value of $M_0$, the equation is as follows (from (14), (16) and (24)):

$$
 f(M_0) = \frac{M_B}{M_0 + M_B} \left[ u(p_B, q_B) - w_c(t) \right] + w_c(t) + c_2
$$

(27)

At the intersection point of of curve hh and DF, E, education market reaches equilibrium. The

---

13In Figure 2, the ways of using public educational resources in flow-out places are inefficient. If it can reduce the educational scale of floating-out, so that it can save these funds to lower school admission charge and improve quality of education. On the condition that no increase of public educational funds, it can decrease the amount of dropout students in floating-out, with higher quality of educational services.

14 The corresponding coordinate origin of curve hh is B, the positive direction of horizontal axis is BOA. Obviously, $f(M_0) < 0$ and $f'(M_0) > 0$, so curve hh slopes and concaves downward; The horizontal line with intercept $w_c(t) + c_2$ is the asymptote of curve hh.
assumption that $M_1$ is big enough makes sure that curve hh and DF won’t intersect on the right of F. Actually, $M_1$ don’t equal to 0, which rules out the possibility that curve hh and DF intersect on the left of D.

The features of this equalization are noteworthy: it exists of drop-out in flow-in district; however, educational resources are surplus in flow-out district. This phenomenon of drop-out is root in the educational gap between flow-out and flow-in districts, therefore, even though the sum of admissible capacity of children from floating families in both flow-out and flow-in districts is no less than $M$, the actual amount of children in floating families, this kind of drop-out still remains. These drop-out children are willing to but cannot admit in some schools in flow-in district, which charge them of quotation $(p_B, q_B)$. The phenomenon is can be called involuntary drop-out.\textsuperscript{15}

Krueger (1974) figured out that in Harris-Todaro model, salaries imposed by administration ($w_B$) are higher than the pay level of clear labor market, which makes the migrants who luckily have employed in the cities gain the rent $w_B - w_A$. It is a kind of competitive rent-seeking that laborers migrate into cities from emigrant places for higher pay in cities. At the same time, the unemployment of migrants in cities can reflect the amount of wasted resources in rent-seeking. Similarly in the education market under this model, due to the educational gap between flow-in and flow-out district, educational authorities impose the charges $(p_A, q_A)$ and $(p_B, q_B)$, which provides rent $(p_B, q_B) - u(p_A, q_A) + c_2$ for children in floating families admitted by schools in flow-in district. School-aged children in floating families migrating into flow-in district from flow-out district for better education resources is also a kind of competitive rent-seeking. At the same time, the drop-out of floating children in flow-in can reflect the amount of wasted resources in rent-seeking.

C. Comparative Static Analysis

According to implicit function theorem (Rudin, 1976, pp. 224-225), partial effect of the variation of 11 exogenous variables to 9 endogenous variables can be deduced from following 9 equations: (6), (7), (8), (23), (11), (13), (14), (16) and (24). The deducing process can be clearly

\textsuperscript{15} Suppose that it is no frictional dropout.
presented at the appendix. The directions of partial effect of every exogenous variable to 5 endogenous variables \((M, M_1, M_2, M_0, j)\) in education market are summarized in Table 1.

Table 1 Comparative Static Results of Population Floating- Education Model

<table>
<thead>
<tr>
<th>Exogenous Variables</th>
<th>(M)</th>
<th>(M_1)</th>
<th>(M_2)</th>
<th>(M_0)</th>
<th>(j)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(p_A)</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>(q_A)</td>
<td>0</td>
<td>+</td>
<td>0</td>
<td>-</td>
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<td>0</td>
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<td>-</td>
<td>+</td>
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<tr>
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<td>-</td>
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<tr>
<td>(M_B)</td>
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<td>(T)</td>
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<td>(N)</td>
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<td>0</td>
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<tr>
<td>(L)</td>
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<td>+</td>
<td>0</td>
<td>0</td>
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<tr>
<td>(c_1)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(c_2)</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>+</td>
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</tr>
</tbody>
</table>

It is constantly true for dropout rate:

\[
\text{dropout} = \frac{M_0}{M_0 + M_2} = 1 - \frac{M_2}{M_0 + M_2} = 1 - j(M_0, M_2) \tag{28}
\]

Obviously, dropout rate and \(j\) present a reverse change form. Note from Table 1, the exogenous variables influencing \(j\) are \(p_A, q_A, p_B, q_B, T, c_2\). It can reach the following proposition.

**Proposition 2:** Other things being equal, the lower the price of education in the flow-in district is, or the higher the education quality in the flow-in district is, or the higher the price of education in the flow-out district is, or the lower the education quality in the flow-out district is, or the older the floating child is, or the higher the left-behind cost is, the higher the dropout rate of floating children will be.

### III. Empirical Analysis
A. Data and Variable Design

We use the 2000 census data and 2005 1% population survey data to test our hypothesis on the dropout rate of floating children. The data consists of two parts: the 1% random subsample from the 2000 census long-table data\textsuperscript{16}, and the 15% random subsample from the 2005 1% population survey data\textsuperscript{17}. The standard time of both surveys is at 0 o’clock on November 1st of the survey year.

The explained variable we are concerned with is the dropout rate of school-aged children in cities, including both local and floating children. Most of the floating children who study in the flow-in districts are in compulsory education stage\textsuperscript{18}, so we limit our research to those compulsory school-aged children\textsuperscript{19}. In China, the statutory school age of compulsory education is six-to-seven years old. To avoid the influence of different school ages, it further limits our sample to those children from 7 to 15 years old. We define “dropout” children as those who are of school age but not study at school without accomplishment of compulsory education at the survey time.

According to the former theoretic analysis, there are seven explanatory variables: whether to be floating child, the education quality of flow-out district $q_A$ and its price $p_A$, the education quality of flow-in district $q_B$ and its price $p_B$, the age of the floating child $t$, and the left-behind costs $c_2$, which are derived from the departure of parents and their children working and studying in different districts.

Further, we define floating children as those who don’t have a hukou in the flow-in cities they live at the survey time\textsuperscript{20}. We collect government education expenditure per student in both the urban and rural areas in the province level from the China Education Expenditure Statistical Year Book 2001 and 2006. We use this indicator to represent the education quality of the district\textsuperscript{21}.

\textsuperscript{16} The sample ratio of 2000 census is 9.5%. More details read “China census data in 2000” (the state council, National bureau of statistics, 2002).
\textsuperscript{17} More details of sampling survey in 2005 read “ 1% population sampling survey data of 2005” (the state council, National bureau of statistics, 2007)
\textsuperscript{18} According to the current college entrance examination system, the examinees must return to their home districts to participate in the exam. The examination papers and text books are different in different districts, which severely restricts the migrant children studying in the senior middle school of the flow-in districts (Zhang, 2003; Sang et, 2009).
\textsuperscript{19} We also exclude the samples of collective hukou.
\textsuperscript{20} To the data limit, the definitions of “local” in 2000 and in 2005 are not entirely comparable. In 2000, “local” means local city or local county, local town, in 2005, “local” means Local County. The 2000 “local” definition is the same as Duan and Liang(2004); according to their definition,
\textsuperscript{21} We use the government expenditure per student of the urban areas in the flow-in district as the expenditure of the migrant children’s flow-in district and the local children’s. A part of the migrant children study in the special migrant children schools which are very crude and simple compared with public schools, so our variable construction is not very good for this.
Admission costs consist of two parts: tuition and the cost paid to meet the entrance requirements of the flow-in district, such as temporary residence permits, living and working certificates. In different districts, and even different schools in the same district, the tuition of public schools charging the floating children is very different. And the admission requirements of different public schools are also various. Unfortunately, we cannot get the exact admission costs data of different districts.

According to our proposition 1, the dropout rate of floating children is higher than that of local children after controlling other covariates. According to proposition 2, the government expenditure per student of flow-in and flow-out districts have positive and negative effects on the floating children’s dropout rate respectively. The age of floating children has positive effect on their dropout rate, and this effect is greater in floating children than that in local children.

Considering the heterogeneity of different families, we choose many other control variables besides the key explanatory variables. They are the gender of school-aged children, the education level of household head (primary school or below, secondary school, high school, college and above), the number of school-aged children in the family (one, two, three or more), family structure (living with parents, single-parent, or alone). For floating children, we further considered the floating duration of the children themselves and their parents.

B. Descriptive Statistics

Table 2 list the sample mean of the variables.

<table>
<thead>
<tr>
<th>Variables</th>
<th>2000</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All children</td>
<td>Floating children</td>
</tr>
<tr>
<td>Dropout rate</td>
<td>0.017</td>
<td>0.035</td>
</tr>
<tr>
<td>Whether floating children</td>
<td>0.100</td>
<td>1.000</td>
</tr>
<tr>
<td>Education expenditure per student in flow-in</td>
<td>1.520</td>
<td>1.610</td>
</tr>
<tr>
<td>districts (thousand yuan)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education expenditure per student in flow-out</td>
<td></td>
<td></td>
</tr>
<tr>
<td>districts (thousand yuan)</td>
<td>1.046</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>11.206</td>
<td>10.786</td>
</tr>
</tbody>
</table>

To the data limit, the standards of migrant durations in 2000 and in 2005 are different. For 2000, the duration measures the time since they arrived the flow-in district, while for 2005, it measures the time since they leave the flow-out district.
<table>
<thead>
<tr>
<th></th>
<th>0.475</th>
<th>0.457</th>
<th>0.477</th>
<th>0.483</th>
<th>0.461</th>
<th>0.486</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education level of household head: primary or below</td>
<td>0.210</td>
<td>0.247</td>
<td>0.206</td>
<td>0.214</td>
<td>0.233</td>
<td>0.211</td>
</tr>
<tr>
<td>Education level of household head: junior middle school</td>
<td>0.411</td>
<td>0.459</td>
<td>0.406</td>
<td>0.433</td>
<td>0.472</td>
<td>0.428</td>
</tr>
<tr>
<td>Education level of household head: senior middle school</td>
<td>0.257</td>
<td>0.226</td>
<td>0.260</td>
<td>0.207</td>
<td>0.181</td>
<td>0.211</td>
</tr>
<tr>
<td>Education level of household head: college or above</td>
<td>0.122</td>
<td>0.068</td>
<td>0.128</td>
<td>0.146</td>
<td>0.114</td>
<td>0.151</td>
</tr>
<tr>
<td>One school age child</td>
<td>0.731</td>
<td>0.606</td>
<td>0.745</td>
<td>0.798</td>
<td>0.757</td>
<td>0.804</td>
</tr>
<tr>
<td>Two school age children</td>
<td>0.211</td>
<td>0.312</td>
<td>0.199</td>
<td>0.158</td>
<td>0.207</td>
<td>0.152</td>
</tr>
<tr>
<td>Three school age children or more</td>
<td>0.058</td>
<td>0.081</td>
<td>0.055</td>
<td>0.043</td>
<td>0.036</td>
<td>0.044</td>
</tr>
<tr>
<td>Live with parents</td>
<td>0.777</td>
<td>0.804</td>
<td>0.773</td>
<td>0.588</td>
<td>0.637</td>
<td>0.582</td>
</tr>
<tr>
<td>Live with single parent</td>
<td>0.066</td>
<td>0.074</td>
<td>0.065</td>
<td>0.233</td>
<td>0.262</td>
<td>0.229</td>
</tr>
<tr>
<td>Live without parents</td>
<td>0.157</td>
<td>0.122</td>
<td>0.161</td>
<td>0.179</td>
<td>0.101</td>
<td>0.189</td>
</tr>
<tr>
<td>Children floating: more than 5 years</td>
<td></td>
<td>0.471</td>
<td></td>
<td>0.417</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children floating: 3 to 5 years</td>
<td></td>
<td>0.145</td>
<td></td>
<td>0.181</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children floating: 1 to 3 years</td>
<td></td>
<td>0.250</td>
<td></td>
<td>0.280</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children floating: less than 1 year</td>
<td></td>
<td>0.134</td>
<td></td>
<td>0.123</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household head floating: more than 5 years</td>
<td></td>
<td>0.517</td>
<td></td>
<td>0.529</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household head floating: 3 to 5 years</td>
<td></td>
<td>0.151</td>
<td></td>
<td>0.166</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household head floating: 1 to 3 years</td>
<td></td>
<td>0.228</td>
<td></td>
<td>0.221</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household head floating: less than 1 year</td>
<td></td>
<td>0.104</td>
<td></td>
<td>0.084</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of observation</td>
<td>28949</td>
<td>2888</td>
<td>26061</td>
<td>56239</td>
<td>7408</td>
<td>48831</td>
</tr>
</tbody>
</table>

Note: (1) Space means not applicable; (2) The data in 2005 is weighted by the sampling weights.

According to Table 2, the dropout rate of floating children is two percentage points higher than that of local children in 2000. In 2005, this gap decreased to 0.6 percent point. For the floating children, the education qualities of flow-in districts are higher than that of flow-out districts: the average government education expenditure in flow-in districts is 54% higher than the flow-out districts in 2000, and 66% higher in 2005.

Of the demographic and social characteristics, there is significant difference between floating children and local children. In average, floating children are younger than local children, in 2000 and in 2005; the gap is 0.5 and 0.4 respectively. The proportion of girls in floating children is lower than in local children. The family educations of floating children are worse than that of local children; especially the household heads’ education level is much lower. Compared with local children, the floating children’s families are more inclined to have more than one child. This may
reflect the difference of enforcement of One-Child Policy among different districts, especially between urban and rural areas. The proportion of floating children not living with their parents is very low.

Most of the floating children are not “mobile” anymore, because the proportion of floating children whose floating duration is more than 3 years is about 60%, and more than 5 years is about 40%. The floating duration of their parents is much longer, more than half of the household head mobile more than 5 years.

C. Empirical Results

The explained variable of the empirical analysis is whether the School-aged Children drop out or not. For the reason that the explained variable is a dummy variable, the paper chooses the logit model23 to analyze the factors which affect the dropout rate. The average marginal effect24 coming from the maximum likelihood25 is listed in Table 3. Model 1 regresses the School-aged children on “whether floating children”, “education expenditure per student in flow-in districts”, “age”, and some other controlled variables relevant to all school-aged children. Model 2 regress the dropout rate of floating children on “education expenditure per student in flow-in districts”, “education expenditure per student in flow-out districts”, “age”, and some other controlled variables relevant to all school-aged children. Model 3 is based on Model 2, added the controlled variables relevant to the floating children. Model 4 regresses the dropout rate of the local children on “education expenditure per student in flow-in districts”, “age”, and other controlled variables relevant to all school-aged children.

Table 3: Logit Regress: Average Marginal Effect

(Independent variable: dropout rate of school-aged children in cities)

<table>
<thead>
<tr>
<th>Independent</th>
<th>2000 年</th>
<th>2005 年</th>
</tr>
</thead>
</table>

23 Probit model is another common used model to deal with binary choice problems. When one outcome of explained variable is rare (the dropout rate researching in this paper is one of those cases), complementary log-log model can also be used (Cameron and Trivedi, 2005, p. 446). We practice using logit, probit, and complementary log-log model respectively. The qualitative results based on the three kind of model are just the same. According to the log-likelihood criterion, logit and complementary log-log model are similar, and all are preferable to probit model. In order to convenient to compare with literature, we list the results of logit model.

24 As a nonlinear model, the coefficient of logit model is hard to explain, but marginal effect has its intuitive meanings: after controlled other variables, the magnitude of dependent variable change caused by the one unit change of the independent variable. To save space, we only report the AME.

25 To a large extent, one city’s education policy is introduced by the specific local government, so the samples in the same city would probably correlate with each other. So we utilize cluster-robust method to measure the variance-covariance matrix of the coefficients.
<table>
<thead>
<tr>
<th>variables</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>Floating</td>
<td>All</td>
<td>Floating</td>
<td>All</td>
<td>Floating</td>
<td>All</td>
<td>Floating</td>
</tr>
<tr>
<td>Whether floating children</td>
<td>0.0215*** (0.0042)</td>
<td></td>
<td>0.0054* (0.0023)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education expenditure per student in flow-in districts (thousand yuan)</td>
<td>-0.0041*** (0.0011)</td>
<td>0.0077 (0.0049)</td>
<td>0.0049 (0.0044)</td>
<td>-0.0051*** (0.0013)</td>
<td>-0.0010* (0.0004)</td>
<td>0.0010* (0.0005)</td>
<td>0.0010* (0.0004)</td>
<td>-0.0017** (0.0006)</td>
</tr>
<tr>
<td>Education expenditure per student in flow-out districts (thousand yuan)</td>
<td></td>
<td>-0.0153* (0.0068)</td>
<td>-0.0153* (0.0068)</td>
<td>-0.0031* (0.0015)</td>
<td>-0.0027* (0.0014)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.0040*** (0.0006)</td>
<td>0.0123*** (0.0024)</td>
<td>0.0120*** (0.0022)</td>
<td>0.0031*** (0.0005)</td>
<td>0.0004 (0.0004)</td>
<td>0.0038*** (0.0011)</td>
<td>0.0038*** (0.0011)</td>
<td>0.0000 (0.0004)</td>
</tr>
<tr>
<td>Girl</td>
<td>0.0009 (0.0015)</td>
<td>0.0168** (0.0062)</td>
<td>0.0153* (0.0062)</td>
<td>-0.0008 (0.0006)</td>
<td>0.0006 (0.0012)</td>
<td>0.0035 (0.0038)</td>
<td>0.0032 (0.0037)</td>
<td>0.0002 (0.0012)</td>
</tr>
<tr>
<td>Education level of household head (reference group: primary or below)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Junior middle school</td>
<td>-0.0109*** (0.0020)</td>
<td>-0.0245** (0.0081)</td>
<td>-0.0238** (0.0081)</td>
<td>-0.0102*** (0.0020)</td>
<td>-0.0103*** (0.0023)</td>
<td>-0.0128*** (0.0046)</td>
<td>-0.0123*** (0.0046)</td>
<td>-0.0100*** (0.0024)</td>
</tr>
<tr>
<td>Senior middle school</td>
<td>-0.0141*** (0.0017)</td>
<td>-0.0308*** (0.0061)</td>
<td>-0.0307*** (0.0062)</td>
<td>-0.0123*** (0.0018)</td>
<td>-0.0114*** (0.0018)</td>
<td>-0.0195*** (0.0037)</td>
<td>-0.0192*** (0.0038)</td>
<td>-0.0103*** (0.0021)</td>
</tr>
<tr>
<td>College or above</td>
<td>-0.0146*** (0.0015)</td>
<td>-0.0233*** (0.0073)</td>
<td>-0.0269*** (0.0060)</td>
<td>-0.0134*** (0.0015)</td>
<td>-0.0127*** (0.0017)</td>
<td>-0.0143** (0.0050)</td>
<td>-0.0144** (0.0049)</td>
<td>-0.0123*** (0.0018)</td>
</tr>
<tr>
<td>Number of school-aged children in the family (reference group: one child)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two</td>
<td>0.0026 (0.0022)</td>
<td>-0.0246*** (0.0059)</td>
<td>-0.0234*** (0.0057)</td>
<td>0.0062** (0.0024)</td>
<td>0.0006 (0.0017)</td>
<td>-0.0081* (0.0038)</td>
<td>-0.0079* (0.0038)</td>
<td>0.0019 (0.0019)</td>
</tr>
<tr>
<td>Three or more</td>
<td>0.0070* (0.0041)</td>
<td>-0.0291*** (0.0060)</td>
<td>-0.0273*** (0.0065)</td>
<td>0.0141** (0.0049)</td>
<td>0.0087 (0.0060)</td>
<td>-0.0098* (0.0047)</td>
<td>-0.0085* (0.0049)</td>
<td>0.0115* (0.0070)</td>
</tr>
<tr>
<td>Whether live with parents (reference group: live with parents)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live with single parent</td>
<td>0.0052 (0.0035)</td>
<td>0.0173 (0.0143)</td>
<td>0.0132 (0.0136)</td>
<td>0.0040 (0.0035)</td>
<td>0.0023 (0.0016)</td>
<td>0.0013 (0.0041)</td>
<td>0.0012 (0.0041)</td>
<td>0.0025 (0.0017)</td>
</tr>
<tr>
<td>Live without parents</td>
<td>0.0024 (0.0023)</td>
<td>0.0492*** (0.0116)</td>
<td>0.0352*** (0.0095)</td>
<td>-0.0018 (0.0020)</td>
<td>-0.0034* (0.0017)</td>
<td>0.0107 (0.0073)</td>
<td>0.0095 (0.0071)</td>
<td>-0.0044* (0.0018)</td>
</tr>
<tr>
<td>Children floating duration (reference group: more than 5 years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 to 5 years</td>
<td></td>
<td>-0.0014 (0.0142)</td>
<td></td>
<td></td>
<td>0.0019 (0.0076)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 to 3 year</td>
<td></td>
<td>0.0372* (0.0175)</td>
<td></td>
<td></td>
<td>0.0115 (0.0080)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 1 year</td>
<td></td>
<td>0.0909*** (0.0258)</td>
<td></td>
<td></td>
<td>0.0232* (0.0122)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household head floating duration (reference group: more than 5 years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The AME of the independent variables is in accordance with the theoretical prediction, and every important AME is significant except for the ‘the government expenditure per student of the flow-in district’ in Model 2 and Model 3 in 2000. It effectively supports the population floating-education model proposed in Part 2.

From Model 1, we can realize that if we control other conditions, floating children’s dropout rate will be higher than the local children. The difference between these two is 2.2 percentage points in 2000, and it decreases to 0.5 percentage points. As it were, according to the difference between floating children and local children’s dropout rate, the year of 2005 is of a great progress compared to 2000. However, if we control other conditions, in 2005 floating children’s dropout rate is 1/3 higher than that of local children.

From Model 2 and Model 3, we can see that as it is expected, the higher the government expenditure per student of the flow-out district, the lower the dropout rate of the floating children; in 2005 the higher the government expenditure per student of the flow-in district, the higher the dropout rate is. In 2000 though the sign is consistent with what expected is, the effect of the government expenditure per student of the flow-in district is not statistically significant. The absolute effect of the government expenditure per student of flow-out districts overweighs that in flow-in district. Comparing Model 2 to Model 3 in the same year, we can see that after adding the controlled variable, the effect of the absolute value of expenditure trends to decrease. The effect of the expenditure is not steady; it is possible that the expenditure data is not in the personal level but in the provincial level. What is more, in flow-in districts, many floating children are educated in

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**Note:** (1) standard error in parentheses; (2) * p<0.05, ** p<0.01, *** p<0.001; (3) the regression of data in 2005 is weighted by the sampling weights; (4) utilize cluster-robust method to measure the variance-covariance matrix of the coefficients

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26 This result is the same as Liang and Chen (2007).
floating children school. Regarding these floating children, the provincial government expenditure per student strongly overrates its education quality. According to the AME of Model 3, if we increase the government expenditure per student of the flow-out district to the flow-in district’s level, in 2000 we can decrease the floating children’s dropout rate by 0.9 percent, and in 2005 we can decrease the floating children’s dropout rate by 0.4 percent. According to Model 4, contrasting to the floating children, the effect of urban local children’s expenditure is negative, that is to say, the mechanism between the local children and the floating children is different; the higher the quality of education, the lower the local children’s dropout rate, but the floating children’s dropout rate in this district trends to increase.

As it is expected, Model 2 and Model 3 show that the age effect on the floating children’s dropout rate is positive\(^{27}\). And the effect is steady, not affected by the number of controlled variable. What’s more, the age effect is amazing: if the floating children grow by one year, the dropout rate would averagely increase by 1.2 percent in 2000 and 0.4 percent in 2005. Compared to Model 4, it is obvious that the floating children’s age effect is more remarkable than it of local children\(^ {28}\).

Now let’s see the effect of other controlled variables on the dropout of floating children through Model 2 and Model 3. In 2000, the dropout of girls trends to be higher than it of boys, but in 2005 without this effect\(^ {29}\). In addition, gender has no effect on the dropout of local children. The higher education householder trends to lower dropout rate\(^ {30}\), no matter where the children are from. The floating children’s enrollment shows “scale economy”: the more floating children in one family, the lower the dropout rate trend; but this is not the case for local children. Not living with parents trends to high dropout rate in 2000, while no this trend in 2005. It shows that the shorter the floating duration, the higher dropout rate, especially in 2000. In 2000, if the householder’s floating duration is less than one year, the children’s dropout rate is lower, while in 2005 the effect of

\(^{27}\) This finding is the same as Lu (2007), but opposite to Guo (2002). We have opposite age effect to Guo (2002) probably due to that Guo’s samples contained the migrant children from 6 to 14 years old; the compulsory law stipulates that the starting age of primary education is 6 or 7, depend on the specific requirements of the different province, so there are many 6-year-old children not go to school. This effect is so remarkable, so we observe that younger children are more prone to drop out of school.

\(^ {28}\) To Model 3 and Model 4 in 2000, the confidence intervals of AME of “age” are \([0.0076, 0.0164]\), \([0.0020, 0.0041]\) respectively, and their intersection is empty set. And To Model 3 and Model 4 in 2005, the confidence intervals of AME of “age” are \([0.0016, 0.0059]\), \([-0.0008, 0.0007]\) respectively, and their intersection is empty set.

\(^ {29}\) Whether there is gender difference on the migrant children’s admission rate, there is no agreement until now.

\(^ {30}\) This finding is the same as Guo(2002).
householder’s floating duration is not remarkable.

**IV. Conclusion**

The Population Movement-Education model proposed in the paper can well explain the reasons of floating children’ dropout in China, and our empirical analysis based on large sample data strongly supports our theoretical model.

This model can well explain the behavior of governments in the flow-in districts: lack of initiative to improve the education conditions of floating children, no motivation to implement the “Two Major Responsible Subjects” policy (Ban and Yu, 2006; Goodburn, 2009). Suppose the following situation: a given city carries out the preferential policies for floating children while other cities do not\(^{31}\). If the city reduces the expenses needed to enroll into public schools for floating children (eg reduce fees, ease the entrance requirements), or improve the quality of education (such as more opportunities of enrollment into leading schools, equal teaching in a mixed class but not separating one for floating children and local children, etc.). It is expected in the model that floating children in other cities and left-behind children in flow-out districts would rush into this city, which would increase the dropout number of floating children and the dropout rate. If public schools in this city increase the admissible capacity of floating children, it will be a corresponding increase of the number of school children in the city, but the dropout rate of floating children in the city will increase proportionally\(^{32}\) due to the floating children rushing from other districts. For a given city, floating children is almost a “unlimited supply”. Moreover, according to the “Two Major Responsible Subjects” policy, the central government requires the local government to enlarge its financial expenditure, but does not give the appropriate financial support (Ge, 2009). Therefore, it seems to be quite difficult even impossible for the local government to improve educational conditions for floating children (expenditure increased while income stay the same, and the large influx of floating children and low-quality laborers), so they are not willing to carry out the policy but compete to race to the bottom.

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31 It is similar with that only one city takes action but other cities do not change.

32 The phenomenon of improving the education conditions of migrant children in a city is observed in some literature, it is named “low land effect” (Ge, 2009; Wu and Liu, 2009).
Therefore, it requires nationwide co-ordination to solve the problem of floating children’
dropout. The affairs of floating children’s education should be taken in the conventional
assessment scope of evaluating the local government’s performance. At the same time, a more
reasonable investment mechanism should be established. The Central Government transfers a
certain amount of fund to the local governments, and the local governments make up the balance.
We hope this system can stimulate the local government to positively carry out the "two major
responsibilities" policy. Currently, the number of local students in compulsory education
decreased quickly, so that the spare resources can be used for floating children's education.
Moreover, it needs every local government of flow-in districts across the country to work together
in order to ease the pressure of the first cities which have taken corresponding measures. The local
governments of flow-out districts should implement the free compulsory education policy with
improvement of their education quality for the aim of narrowing the gap between them and the
flow-in districts and promoting a balanced distribution of primary education. On one hand, it can
improve education quality of left-behind children; on the other hand, it also helps to reduce the
dropout number of floating children and the dropout rate in flow-in districts, which will lower the
costs in the period of restructuring in China and create relatively more stable educational
environment for the floating school-aged children

The paper can also be extended from the following dimension: Introducing liquidity constraints
of floating family under consideration of the possibility of dropout caused by family financial
crisis; controlling more factors in the empirical analysis, such as whether floating children enroll
in "special schools for floating children", school fees, enrollment requirement, etc.

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Appendix. Derivation of Comparative Static Natures of the Population Floating-Education Model

The nine equations determining the equilibrium of labor market and education market (equations (6), (7), (8), (23), (11), (13), (14), (16), (24)) are arranged as follows:

\[
N - N_1 - N_2 = 0 \quad (29)
\]

\[
D_A(w_A) - N_1 = 0 \quad (30)
\]

\[
D_B(w_B) - N_2 = 0 \quad (31)
\]

\[
w_A + c_1 + c_2 - w_B = 0 \quad (32)
\]

\[
M - lN_2 = 0 \quad (33)
\]

\[
M - M_1 - M_2 - M_0 = 0 \quad (34)
\]

\[
\frac{j - M_2}{M_0 + M_2} = 0 \quad (35)
\]

\[
M_2 - M_B = 0 \quad (36)
\]

\[
u(p_A, q_A) - ju(p_B, q_B) - (1-j)w_c(t) - c_2 = 0 \quad (37)
\]

The nine equations determine the relationship between the nine endogenous variables \( (N_1, N_2, w_A, w_B, M, M_1, M_2, M_0, j) \) and the eleven exogenous variables \( (p_A, q_A, M_A, p_B, q_B, M_B, t, N, l, c_1, c_2) \). For better presentation, we record these variables as \( (y_1, y_2, ..., y_9) \) and \( (x_1, x_2, ..., x_{11}) \), and record the equations (29) ~ (37) as:

\[
F_1(y_1, ..., y_9, x_1, ..., x_{11}) = 0
\]

\[
\ldots
\]

\[
F_9(y_1, ..., y_9, x_1, ..., x_{11}) = 0
\]

For every variables \( (y_1, y_2, ..., y_9; x_1, x_2, ..., x_{11}) \), the functions \( (F_1, F_2, ..., F_9) \) all have continuous partial derivatives; moreover, there is point \( (y_{10}, y_{20}, ..., y_{90}; x_{10}, x_{20}, ..., x_{110}) \) satisfying equation (38), and the Jacobian determinant:
\[
|J| = \begin{vmatrix}
\frac{\partial F_1}{\partial y_1} & \cdots & \frac{\partial F_1}{\partial y_n} \\
\vdots & \ddots & \vdots \\
\frac{\partial F_m}{\partial y_1} & \cdots & \frac{\partial F_m}{\partial y_n}
\end{vmatrix}
\]
\[
= \begin{vmatrix}
-1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & -1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0
\end{vmatrix}
\begin{vmatrix}
-M_0 \\
1
\end{vmatrix}
\begin{vmatrix}
\frac{M_2}{(M_0 + M_2)^2}
\end{vmatrix}
\]
\[
= \left[D_A(w_a) + D_B(w_b) \right] \left[u(p_a, q_a) - w_c(1) \right] \frac{M_2}{(M_0 + M_2)^2}
\]

(39)

According to (9), (10), (17), the result of (39) is negative, not equal to 0. Therefore, according to the implicit function theorem (Rudin, 1976, pp. 224-225), there is a 11-dimensional neighborhood of point \((x_{10}, x_{20}, \ldots, x_{110})\), in this neighborhood, there is the implicit function:

\[
y_i = f_i(x_1, \ldots, x_{11}) = 0
\]

\[
\ldots
\]

\[
y_9 = f_9(x_1, \ldots, x_{11}) = 0
\]

And the implicit function is continuously, with continuous partial derivatives for \(x_1, x_2, \ldots, x_{11}\), and

\[
\frac{\partial y_k}{\partial x_i} = \left| \frac{J_k}{|J|} \right| (i = 1, \ldots, 11; k = 1, \ldots, 9)
\]

(41)

where \(\left| J_k \right|\) is a determinant, which is the calculated through the ith column of following matrix (42) replacing the kth column of Jacobian determinant\(|J|\):

\[
\left(\frac{\partial (F_1, \ldots, F_m)}{\partial (x_1, \ldots, x_{11})}\right) = \left(\begin{array}{ccc}
\frac{\partial F_1}{\partial x_1} & \cdots & \frac{\partial F_1}{\partial x_{11}} \\
\vdots & \ddots & \vdots \\
\frac{\partial F_m}{\partial x_1} & \cdots & \frac{\partial F_m}{\partial x_{11}}
\end{array}\right)
\]
\[
\begin{pmatrix}
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\end{pmatrix}
\]

\[
\begin{pmatrix}
\frac{\partial u(p_x, q_x)}{\partial p_x} & \frac{\partial u(p_x, q_x)}{\partial q_x} & 0 & -j \frac{\partial u(p_x, q_x)}{\partial p_x} & -j \frac{\partial u(p_x, q_x)}{\partial q_x} & 0 & -(1-j)w_i(t) & 0 & 0 & 0 & -1 \\
\end{pmatrix}
\]
(42)

From (39), (41), (42), we can calculate the partial derivatives of various exogenous variables on endogenous variables. To save space, we list only the partial derivative of the exogenous variables on the enrollment probability \( j \) and their sign:

\[
\frac{\partial j}{\partial p_x} = \frac{\partial u(p_x, q_x)}{u(p_x, q_x) - w_i(t)} < 0 
\]
(43)

\[
\frac{\partial j}{\partial q_x} = \frac{\partial u(p_x, q_x)}{u(p_x, q_x) - w_i(t)} > 0 
\]
(44)

\[
\frac{\partial j}{\partial M_A} = 0 
\]
(45)

\[
\frac{\partial j}{\partial p_y} = \frac{-j \frac{\partial u(p_y, q_y)}{\partial p_y}}{u(p_y, q_y) - w_i(t)} > 0 
\]
(46)

\[
\frac{\partial j}{\partial q_y} = \frac{-j \frac{\partial u(p_y, q_y)}{\partial q_y}}{u(p_y, q_y) - w_i(t)} < 0 
\]
(47)

\[
\frac{\partial j}{\partial M_B} = 0 
\]
(48)

\[
\frac{\partial j}{\partial t} = \frac{-(1-j)w_i(t)}{u(p_x, q_y) - w_i(t)} < 0 
\]
(49)

\[
\frac{\partial j}{\partial N} = 0 
\]
(50)
\[
\frac{\partial j}{\partial l} = 0 \quad (51)
\]
\[
\frac{\partial j}{\partial c_i} = 0 \quad (52)
\]
\[
\frac{\partial j}{\partial c_2} = \frac{-1}{u(p_h, q_h) - w_i(t)} < 0 \quad (53)
\]

The signs of these partial derivatives can be deduced from (3), (4), (14), (17), (18). Table 1 in the text lists the sign of the partial derivatives of five endogenous variables on exogenous variables in the education market.