How Does Central Authority Assign Provincial Leaders? Evidence from China*

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Abstract

We analyze how central authority assigns provincial leaders to 31 provinces in post-reform China. Using data containing provincial chief leaders who are rotated between provinces from 1993 to 2008, we find that the result of central assignment depends on whether the central authority emphasizes national output or regional development balance. We show that positive assortative matching between leaders and provinces is implemented from early 1990s to early 2000s when central authority concerns more in achieving larger national output. After early 2000s, it turns to be negative assortative matching when central authority concentrates more on reducing regional disparity. The results are robust to various sensitivity tests.

JEL Classification: D83; H11; H77

Key words: Assignment; Rotation; Assortative Matching

1 Introduction

In China, the central authority has full control over the appointment and turnover of regional leaders (Huang, 1996, 2002). On the one hand, the personnel control over regional leaders serves as one important tool for central authority to motivate regional leaders to follow central policies (See Maskin, Qian and Xu, 2000). On the other hand, the provincial leaders play vital roles in the progress of economic development when they compete for promotion (Chen, Li and Zhou, 2005; Li and Zhou, 2005). Thus, the issue of promotion and rotation of provincial leaders spawns a large body of literatures.

Promotion enables the officials to climb up to higher level of the political ladders, and the perspective of promotion gives incentives to regional officials in lower levels to undertake tasks in the benefits of the central authority (Maskin et al, 2000). So there are incentive issues in it. However, rotation, which is often implemented by central authority from time to time, forces the

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officials at the same level to work at different places. This issue is worth noticing, not only for its incentive effect, but also for its matching effect. In this paper, we try to explore the result of assignment between officials and provinces managed by central authority. When assigning the provincial leaders to different localities, the central authority usually takes the following factors into consideration: the economic characteristics of provinces and the leaders' abilities in developing regional economy.[1] Knowing the potential ability in developing economy, central authority assigns appropriate leaders to each province by considering the characteristics of leaders and provinces based on its objectives. Based on the results of assignment, could it be positive assortative matching, or negative assortative matching between provincial officials and provinces? The objective of this paper is to answer these questions.

We develop one simple conceptual framework, in which current output is generated based on the previous economic development level and the economic growth rate induced by current leader's ability and regional endowment, to show how central authority allocates officials with heterogeneous abilities to different provinces. We derive that it is complementary between previous economic development level and leader's ability in generating regional output, so economic efficiency requires that positive assortative matching should be made between officials and provinces. The assignment between leaders and regions depends on the objective of central authority. This objective function is the exogenous force that determines the assignment results by allowing for different characteristics of regions and leaders. Both economic output and regional balanced development are concerned in the objective function of central authority but with different emphasis in different phases of economic development. Hence, given the complementarities between production factors, if national output is more emphasized, central authority will implement positive assortative matching between leaders and regions (Becker, 1973, 1981). However, if balanced development among regions is more concerned by central authority, negative assortative matching would be made because positive assortative matching will generate larger income inequality (Fernandez and Rogerson, 2001; Mare, 1991; Fernandez et al, 2005).

How leaders with heterogeneous abilities are assigned to provinces with different development levels by central authority is the main question in this paper. The allocation of leaders to provinces shares some similarities with matching theory (Jovanovic, 1979b; Allgood and Farrell, 2003). Jovanovic (1979b) raises three assumptions for the matching model in labor market to interpret the job separations. Firstly, workers produce different outputs cross jobs. Secondly, wage is flexible, and workers and employers could negotiate wages. Thirdly, there is information asymmetry in

[1] Roles of leaders in determining economic performance have drawn much attention in the literature. Jones and Olken (2005, 2009) identify the differences before and after the replacement of national leaders, and they show that national leaders have significant effects on economic growth, especially in autocratic nations. One potential problem is to identify the causative effect of leader on economic growth, because it might be the case that growth change is the driving force for leader's replacement. To avoid such problem, Jones and Olken (2005) consider the deaths of national leaders while in office caused by exogenous shocks, such as accident or illness, therefore, the change of leaders and the timing of this change is not related to the economic development. Jones and Olken (2009) estimate the change of leadership caused by assassinations. They compare the cases where leaders were killed and leaders survived from the assassination. Whether a leader could survive is exogenous given the weapon used in the assassination (Jones and Olken, 2009). Li and Zhou (2005) find that Chinese provincial leaders compete for promotion by improving provincial economy. From a micro level, Bertrand and Schoar (2003) explore the performance of firms in US by identifying the personnel "style" of managers. They find that CEO has significant effect on firm performance and different CEOs have different effects based on the manager-firm panel data.

the two sides of matching market. The worker's turnover happens when new information is accumulated under some circumstances. The model predicts that it is less likely to separate jobs as job tenure increases, because mismatch should have been found and deleted at an earlier stage, and this is consistent with empirical evidence. Allgood and Farrell (2003) try to understand the role of job-match heterogeneity in the CEO's turnovers empirically, especially the turnovers within the first five years. Their evidence is consistent with the predictions of Jovanovic (1979b). The possibility of turnover increases before the fifth year of the tenure and decreases afterwards. This explanation of turnovers does not deny the incentive problem and the problem of monitoring of CEOs, but add more understanding of CEO-firm match.

In terms of matching in marriage market, Becker (1973) proves that positive assortative matching maximizes the total output under the assumption that the matching types are complementary. He builds a household production function and derives that it is complementary between characteristics of men and women in producing household output when holding other characteristics fixed. In addition, he also gets negative assortative matching for some traits, for example wage rate, when the correlations for these traits between men and women are substitutes. The assumption of complementarities between matching types is an important assumption to the assignment result (Li and Suen, 2000; Damiano and Li, 2007; Tervio, 2008). Tervio (2008) uses a complementary production function to generate positive assortative matching between managers and firms.[2] Damiano and Li (2007) apply this standard assumption that it is complementary in matching value function, to consider how intermediation as a monopoly matchmaker achieves efficient matching in the two-sided matching market using a schedule of entrance fees to sort different types of agents. Li and Suen (2000) apply the complementary production function to analyze the early matching market.[3]

The assignment of leaders to provinces is different from the literatures of matching in the following ways. (1) Central authority behaves as a monopoly matchmaker, and determines the assignment result between leaders and provinces.[4] There is no free market for matching between leaders and provinces. This mechnism is important for the development in China. Blanchard and Shleifer (2001) compare the development in China and Russia based on different effects of federalism and political centralization. They point out the importance of political centralization: federalism plays great role in economic development, but this role relies on the political centralization. And this happens in China but not in Russia. (2) There is no negotiation about wages between provincial leaders and provinces or central authority. (3) Provincial leaders concern more on political promotion than wage. (4) There is no power of each province to take actions to attract more capable leaders.

In this paper, the sample of rotated leaders who have worked in different provinces is used to

[2] This assignment is used to explore the differences in CEO pay, which depends on the distribution of firm size and CEO abilities.

[3] They find higher expected workers would face greater risks of payoff in later matches, so that they match with lower expected types of job to avoid risks.

[4] The positive assortative matching or negative assortative matching is terms of the result of central assignment. Because central authority behaves as a monopoly matchmaker, the matching between provincial leaders and leaders is different from the mathing in marry market or labor market.

look at the result of assignment. The economic performance signifies the leader's ability (Hermalin and Weisbach, 1998). The average total factor productivity (TFP) growth rate over the tenure is derived to get the leader's ability in developing economy. Because all the rotated provincial leaders work under the same incentive framework, the average TFP growth rate could represent the provincial leader's ability.[5] The rotation could avoid the possible endogenous problems when estimating the correlations between ability and economic development level. Correlation coefficients, Spearman rank correlation coefficients and regression coefficients between leader's abilities and provincial GDP per capita one year before rotation is used to test the assortative matching (Fernandez et al, 2005; Mendes, Van den Berg and Lindboom, 2007; Mion and Naticchioni, 2009).

We find that the assignment result does not follow one constant way. The empirical evidence suggests that from early 1990s to early 2000s, central authority implements positive assortative matching by assigning provincial leaders with higher abilities to more developed regions, and this is to achieve larger output in the whole nation given the complementarities between leaders and provinces. During this time periods, the central job for the Party and government is to improve economic growth, and it is allowed that some regions could get rich in advance. Positive assortative matching between production factors could increase the income inequality (Fernández and Rogerson, 2001; Mare, 1991; Fernández, Guner and Knowles, 2005), and negative assortative matching could reduce such income inequality. Accompanying the fast economic growth, large regional disparity increases quickly, and this has raised the attention of central authority with significant policies responses (Zhang, 2006; Démurger, 2001; Démurger et al, 2002)[6]. After early 2000s, negative assortative matching is implemented by allocating leaders with higher abilities to less developed regions, and this indicates that more attention is paid to reduce regional disparity.[7] Central authority makes the tradeoff between efficiency and equality in different time periods of reform.

We contribute to the literatures by finding how assignment is done between leaders and provinces. Previous literatures on the political turnovers (Bo, 1996; Maskin et al, 2000; Li and Zhou, 2005; Chen et al, 2005) concentrate on how career incentives determine the local leader's behaviors in developing provincial economy[8]. They explore how central authority promotes and dismisses provincial leaders in the cadre evaluation system. Bo (1996) studies the political mobility of Chinese provincial leaders systematically in the period between 1949 and 1994. He proposes that both economic performance and revenue contribution to central government are important factors in determining the political mobility, while the latter matters more than the former for leaders'

[5] To get CEO's ability, Hermalin and Weisbach (1998) discuss the determinants of the board in a bargaining process. They propose that board of each firm obtains CEO's ability from the realized earnings. The firm performance signifies the leader's ability. Their model obtains several predictions about the relationship between CEO and board which are consistent with empirical findings. It extends the matching model of Jovanovic (1979) because it allows endogenous monitoring decisions (See Hermalin and Weisbach, 1998). But they only focus on the monitor role of board over hiring and firing management and ignore other roles of board in firm management.

[6] Urban-rural inequality is also one important dimension of income disparity.

[7] Actually, the regional disparity in China turns to be larger since the outset of economic reform (Demurger, 2001, 2002; Jones et al, 2003). On average, coastal provinces grew faster than inland provinces. The negative assortative matching might be considered as one potential way to mitigate this problem.

[8] Different methods are applied in the previous literatures for political turnovers. Bo (1996) applies multinomial logit model. Ordered probit model is used in Li and Zhou (2005) and Chen et al (2005).

promotion. The analysis covers both the periods before and after economic reform. After economic reform, the promotion criteria changes from political attitudes to actual achievement[9]. He raises the question of how economic performance affecting political mobility and many literatures give more detailed research afterwards.

Li and Zhou (2005) find that the possibility of promotion of provincial leaders could increase with their average economic performance over the tenure, and the likelihood of termination will decrease with their average economic performance using data from 1978 to 1995. This reflects that central authority uses personnel control as a tool to motivate provincial leaders to generate higher economic growth rate. They contribute to the literatures by identifying the roles of local government, for example, in encouraging the growth of private firms (Qian and Weingast, 1997), induced by the personnel management system. Maskin et al (2000) suggest that M-form structure could facilitate yardstick competition, and they provide evidence that leaders from regions with better performance is more possible to get promoted by showing positive correlation between changes of relative economic performance in one region and the number of central committee members from that region using data from 1986 to 1991. Chen, Li and Zhou (2005) extend these studies to cover a longer time period from 1979 to 2002. They provide further evidence for the career concerns of provincial leaders using same empirical method as Li and Zhou (2005). They show that political turnover is not only positively related to their own performance, but also related with the performance of the immediate predecessor negatively.

Extending current literatures, in this paper, our contribution is to consider the personnel control over provincial leaders from a more detailed perspective that how central authority allocates one leader to a province to fulfill its objectives in propelling economic development and keeping regional balance. We connect the central personnel control and regional economic development to identify the effects of central authority and provincial leaders in China's economic growth.

The remainder of the paper is organized as follows. In the following section, we provide general introduction to the personnel control for provincial leaders in China and the introduction about central objective in economic development. Section 3 provides the conceptual framework. Section 4 discusses the empirical methods. In section 5, we describe the data that is used in this paper. Empirical results of central assignment are shown in section 6. Section 7 gives an alternative explanation, and section 8 discusses the results of robustness check. In the final part, we conclude the paper.

[9]Since 1978, the cadre evaluation system has been reconsidered. In 1979, one document issued by Organization Department of Central Committee states that the evaluation system should be based on "political thought, organizational and leadership abilities, familiarity with substantive issues, and democratic work style, as well as actual achievement" (See Whiting, 2001). Central authority pays more attention on actual achievement instead of political attitudes after 1978.

2 Personnel control and central objectives

2.1 Personnel control over provincial leaders

Chinese government behaves in a centralized structure and it is a multidivisional-form hierarchy structure[10] (Maskin et al, 2000). Central committee of the Party and State Council are the highest decision makers. Specifically, Politburo standing committee of central committee is the supreme decision-making body, and State Council is responsible for transferring corresponding decisions into real policies (Huang, 2002). Department of organization under the control of central committee is the primary agency for cadre management. Ministries and provinces are below State Council, and they are in the same bureaucratic rank. Provincial leaders and ministry leaders are like the middle-level managers in a company with many departments (Li and Zhou, 2005). Provincial top leaders and ministry top leaders are appointed by the Politburo[11].

Central authority controls turnovers of provincial leaders through appointment, promotion, rotation, termination, and cross-posting[12] (Huang, 2002). Each turnover decision is not arbitrary, but based on a system of standards and the performance of the leader under consideration (See Huang, 2002). Local economic development has become one of the most important conditions to measure officials' performance (Li and Zhou, 2005), because since the start of economic reform, improving economic development turns to be the central task of the party and government officials (Maskin et al, 2000).

Rotation of leaders among equally-ranked positions such as provinces or ministries is one important way of turnover. It is regulated that all leaders at county level or above should be rotated. Leaders at county level are rotated within prefecture or province, and leaders at prefecture level should be rotated within province or among provinces. Provincial leaders are rotated among provinces or between provinces and central departments. The official explanation for the rotation is to prevent factionalism by requiring leaders to work in new position of another province (Huang, 2002)[13]. Through regular and frequent rotations, leaders do not have large incentives to violate central policies as they could not gain interests related to current positions, as they will leave in a short time. Besides, rotation could reveal information to the successor and central authority,

[10] In China, "there are 31 provincial governments, 2400 county governments, about 30000 township governments, and around 40 ministries in the central department" (Huang, 2002).

[11] Since 1983, it is regulated that cadres are managed by leaders immediately above them (Huang, 1996).

[12] Cross-posting refers to the practice that "an official is simultaneously posted to two positions. One is usually a seat on the Politburo, and the other position is in ministerial or provincial bureaucrats" (See Huang, 2002).

[13] In 1962, Deng Xiaoping pointed out that rotation of leaders is one important form of managing leaders. Since early 1980s, central authority decided to rotate the leaders at county level. In 1990, one formal decision "Central Committee of the Communist Party's decision about Rotation Party Leaders and Government Leaders of China" required that leaders at the provincial level should be rotated among provinces or between provinces and central departments. If one leader worked in one region or department for too long time, she should be rotated among regions or departments if she does not get promotion or demotion. Rotation of leaders is important mechanism in cadre management. In 1999, a temporary rotation document "The Temporary Regulation for Rotation of Party Leaders and Government Leaders" was implemented and it gave detailed introductions about the requirement for rotation. And this document turns to be one formal regulation in 2006, "The Regulation for Rotation of Party Leaders and Government Leaders ". Leaders who have been worked in one region for long time, leaders who need to increase working experiences to improve the leading abilities, or leaders who should avoid other colleagues, are all required to be rotated. For example, leaders who have been worked in one position for more than 10 years must be rotated. The rotation could be implemented among regions, departments, between regions and central department or state-owned enterprises.

which is helpful to get complete assessment to this leader. Moreover, rotation of leaders could be helpful to the connection between regions. The successful experiences or useful lessons in one region could be easily introduced to other regions through leader's rotation. Finally, the rotation among provinces could increase the working experiences and skills of solving different problems for provincial leaders.

To understand the personnel control, it is necessary to connect it with the process of economic development. Naughton (2008) divides the economic reform in china into two periods. The first period is from 1978 to 1993, and second period is 1994 and afterwards. In the first period, the reform is "top-down, tentative, exploratory and focusing on a few key sectors" (See Naughton, 2008). Policies are decentralization of power and devolution of resources. The main driving force for economic growth is state owned enterprises (SOE) and township and village enterprises (TVE). Fiscal contract system is implemented, and it regulates the amount of revenue contributed to central government. Local government could keep the remaining revenue. The budget revenue and SOE profits declines through the early 1990s, which signifies the inability to implement comprehensive reforms. Since 1994, the overall economic environment changes, and decisive decisions have been made and implemented quickly. Private firms are playing more important roles in economic development. "A deeper and well-planned reform emerged after 1993" (See Naughton, 2008). The older leaders have left from the leadership, and younger leaders come into the leadership. This is helpful to the implementation of new decisive policies. In October 1992, adoption of building one socialist market economy was firstly raised in the 14th Communist Party Congress, which is considered as the end point of transition (see Naughton, 2008). The third Plenum of the 14th Congress in 1993 proposed the outlines of developing the market economy. Various deeper reforms in fiscal, tax, foreign trade and foreign exchange have been undertaken[14]. Similar as Naughton (2008), in this paper, we confine our analysis to this period after 1993.

2.2 Central objectives in economic development

Since the outset of economic reform, improving the economic growth has been the central job for the Party and government, especially in the earlier stage of the reform (Xu, 2010). More preferential policies are given to coastal regions than western and central regions (Chen and Fleisher, 1996; Démurger, 2001; Démurger et al, 2002; Jones et al, 2003). In 1979, 3 special economic zones were built in Guangdong, and 1 special economic zone was set up in Fujian in 1980. 14 coastal cities were open and 10 economic and technological development zones were set up in 1985. 2 economic and technological development zones were set up in Shanghai in 1986. In 1990, Pudong new area was built in Shanghai. More preferential policies are given to these regions. The distribution principle was to give priority to efficiency with due consideration to fairness, encouraging some people and some regions to become rich first.

Those economic policies enlarge the regional disparity between eastern regions and inland regions (Xu, 2010)[15]. The Open-Door policy benefits eastern provinces to a large extent in the way

[14] For example, fiscal contract system is replaced by tax assignment system which has increased the incentives of local government to improve economic growth and increased the fiscal capacity of central government.

[15] Inland regions include central and west provinces. The items of "inland regions", "non-eastern regions" and

of attracting more FDI and promoting international trade. Fiscal decentralization decreases the subsidies to the less developed provinces. Dual track prices decrease the prices of raw materials that are mainly produced in western and central provinces (See Démurger et al, 2002). Démurger (2001) shows that large regional disparities exist in growth performance among provinces as economy develops in China. On average, coastal regions develop faster than inland regions. In figure A1, we plot the ratio of average real GDP per capita between non-eastern regions and eastern regions from 1975 to 2008 (Fleisher et al, 2010). The ratio keeps decreasing since early 1980s. In 1980 the ratio is 0.55, and it reduces to 0.39 in 2008. In figure A2, regional inequality between regions is shown by the coefficient of variation of real GDP per capita (Naughton, 2002; Fleisher et al, 2010). The variation coefficient increases quickly since 1990s. The gap in economic development is larger between eastern regions and non-eastern regions since early 1990s. Jones et al (2003) find that big variations exist in economic growth rates among geographic regions. In 1999, the GDP per capita in western regions is only 41.3% of GDP per capita level in eastern regions. Large regional disparity will reduce the economic and political stability, and even affect the unity of the nation (Xu, 2010). Without the development of western regions, there is no national development. Western region takes 71.5% of national area, and 82% of land borders are in western regions. Many minorities are living in western regions, and the regional problems are complex. And western regions are the most concentrated regions for people living in poverty. In addition, it is very important to protect environment in western regions, as most forest, lakes, grassland, and origins of big rivers are located in western regions.

To achieve the balance of development among regions, reducing development disparity is more concerned by the central authority since early 2000s. State Council (2000) raised that more tasks should be done to develop western and central regions, and increasing infrastructure investment in these regions is one of the most important tasks[16]. To build a Well-off Society in an all-round way was raised in 2002, and it is emphasized further afterwards. In the third plenum of 16th Party Congress in 2003, the framework of how to complete the socialist market economy was raised, and regional disparity is given more concern. Current generation of leadership has paid much attention to decrease regional disparity and achieve regional harmonious development (Chen and Zheng, 2008). In 2003, after Wen Jiabao was elected to be premier, he pointed out that two of the most important jobs for central government are to achieve coordinated development between urban and rural areas, and to achieve coordinated development between eastern regions and inland regions. Wen Jiabao (2004) declared that "To attain the well-balanced regional development, we should continue to develop the western regions, rejuvenate the northeast old industrial base, speed up the central growth, and encourage eastern development". In the 17th Communist Party Congress in 2007, central authority continues to emphasize the importance of harmonious development among regions, and keeping on building the Well-off Society. The conference of 10-year anniversary of Western Development Program held in 2010 confirms the achievements of the program, and points

"central and west regions" are interchangeable.

[16]Besides infrastructure investment, other jobs are also emphasized, for example, strengthening agriculture development, increasing tourism, improving environment, restructuring industry, increasing other public investment, e.g., education, public health, etc.

out that the program should be further implemented to improve the development of western regions.

Practical actions are taken to develop western and central regions. Grand Western Development Program[17] is implemented in 2000 to develop the less developed regions in western regions. From 2000 to 2008, 102 large projects have been implemented, and total investment amount is more than 1740 billion Yuan[18] in western regions. The growth rate of investment in fixed asset is over 20% annually since 2003. From 2000 to 2009, the average GDP growth rate in western regions is 11.9%. The traffic mileages for railway and highway are 1.5 times and 2.8 times of the levels in 2000 respectively. The electronic installed capacity is 5 times than the level of 2000. Until 2009, people's income levels are more than 2 times than the level of ten years ago. From 2001 to 2008, central financial support to reduce poverty is around 60 billion, and this is 62.9% of the total financial support distributed to all the provinces. The protection and construction of environment is also making steady progress. Until the end of 2008, 400 million acres of forest are planted.[19] In addition, Rejuvenization of Northeast Old Industrial Base is raised in 2003. From 2004 to 2006, the average GDP growth rate in northeastern region is 12.6%, which increases 2.6% than previous speed. Rise of Central China[20] was raised in 2004, and it is another important effort to make consistent developments in whole nation.

Various actions have been taken to reduce regional disparity. In table A1 and A2, we provide the average amount and growth rate of fixed asset investment and central transfers to local government in eastern and inland regions (Chen and Groenewold, 2010). From table A1 and figure 1, it is obvious to see that growth rate of fixed asset investment is greater in central and west regions than eastern regions since late 1990s, and it keeps increasing since 2004.[21] In table A2 and figure 2, we compare the amount of central transfer to local government in different regions. Central transfer starts in 1994, when tax assignment system replaced fiscal contract system. The main purpose of central transfer is to balance regional disparity in government income, which is induced by endowment difference or economic development difference, and make sure that local government could provide enough social services. It is one important method of income redistribution. We find that central government transfers more to central and west provinces than eastern regions since late 1990s, and this distance between eastern and inland regions is turning to be larger since early 2000s. Similarly, the growth rate of central transfer in central and west regions is higher than eastern regions since 1995 with small exceptions in 2002 and 2003.

Lastly, we plot the growth rate of GDP per capita in western and eastern regions from 1993 to 2008 in figure 3. It is quite obvious that since 2002, the average growth rate of GDP per capita is much faster in non-eastern regions. While before 2002, eastern regions grow faster for most of the years. This reflects that various actions to promote the development of western regions are effective.

[17] The mains provinces that are covered by the Grand Western Development Program are Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shannxi, Gansu, Qinghai, Ningxia, Xinjiang, Inner Mongolia and Guangxi. Western regions take 71% of the total area of China.

[18] The data resource is: www.xinhuanet.com

[19] More actions are also taken to protect big rivers and mitigate sandstorm.

[20] Central regions include 6 provinces, Shanxi, Henan, Hubei, Hunan, Anhui, Jiangxi.

[21] Total amount of investment is larger in eastern regions because of the original development level and the preferential policies since 1978.

Figure 1 Increasing rate of investment in fixed asset in east regions, central and west regions from 1993 to 2009

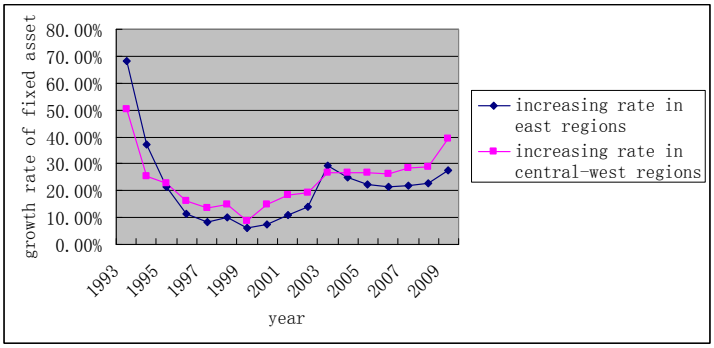
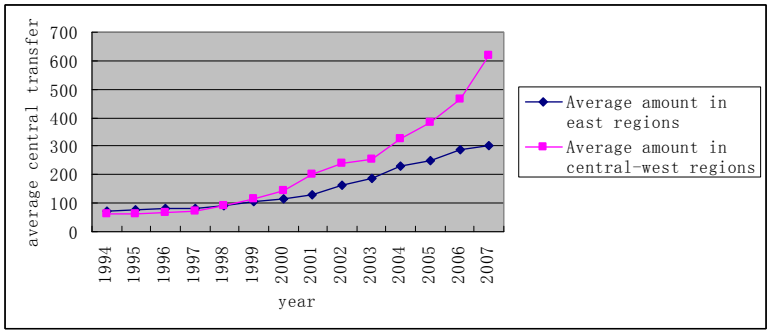


Figure 2 Average transfers from central government to local governments in east regions, central and west regions from 1994 to 2009



3 Conceptual framework

We provide one simple framework to explain how central authority assigns regional leaders. Central authority allocates leaders with different abilities to each province based on its objectives in developing national economy.

Suppose there are N regions in the whole nation, and two time periods, $t-1$, and t. The output Y_t^i at time t in region i is generated based on its previous output level Y_{t-1}^i and the growth rate g_t^i.

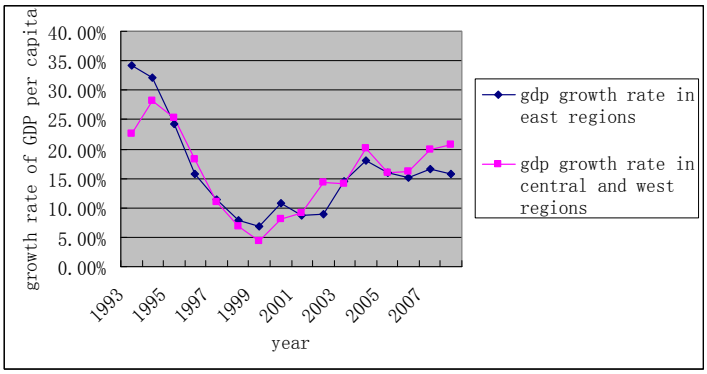
$$Y_t^i = Y_{t-1}^i(1+g_t^i) \tag{1}$$

The growth rate of output in one region is a function of local leader's ability A and provincial endowment E.

$$g_t = g_t(A, E) \tag{2}$$

More capable leaders could generate higher speed of economic growth, and better endowment is helpful to achieve faster economic growth. The function g has this characteristic,

Figure 3 The growth rate of GDP per capita in east, central and west regions from 1993 to 2008



$$\frac{\partial g}{\partial A} > 0, \frac{\partial g}{\partial E} > 0$$

Obviously, the leaders will affect the total output of the region by changing the economic growth rate.

$$Y_t^i = Y_{t-1}^i[1 + g_t^i(A, E_i)] \tag{3}$$

Equation (3) incorporates the analysis in equation (1) and (2), the economic output is based on the economic output in previous period and the growth rate generated by leader's ability and provincial endowment.

In equation (3) it is positive cross derivative between leaders' ability A and the previous output level Y_{t-1}^i in the function of Y_t^i.[22]

$$\frac{\partial^2 Y_t^i}{\partial A \partial Y_{t-1}^i} > 0$$

Given the complementarity between leader's ability and the previous output level, the efficiency in a frictionless matching market requires that positive assortative matching should be made (e.g., Becker, 1973, 1981; Li and Suen, 2000; Damiano, Li and Suen, 2005; Damiano and Li, 2007; Terviö, 2008). Therefore, to generate the largest national output, the most capable leader should be allocated to the region with the largest Y_{t-1}, and the second most capable leader should be assigned to the region with second largest Y_{t-1}, and so on. Obviously, the regional disparity between better developed region and less developed region is larger after positive assortative matching. This has been proved in the literatures (Fernandez and Rogerson, 2001; Mare, 1991; Fernandez et al, 2005).[23]

[22] The production function is determined by A and Y_{t-1}^i. For simplicity, we do not include other factors, for example, investment.

[23] Mare (1991) agrees that more educational homogamy could increase the inequality for family and the inequality in social development of their offspring. Fernandez and Rogerson (2001) extend the analysis of Kremer (1997) by considering the interaction of changes in the distribution of education or skills and changes in prices for skilled and unskilled labor. They prove that if the proportion of marriages with positive assortative matching is higher, the income inequality will increase. In this calibrated model, the increased proportion of marriage with perfect sorting will decrease the fraction of children entering college or becoming skilled. Once the fraction of skilled workers or educated workers decreases, the wage of skilled workers will increase and the wage of unskilled workers

The assignment in our case is not done in a frictionless or competitive market, but managed by the central authority, which behaves as a monopoly matchmaker.[24] The matchmaker's objective function is the exogenous force that determines the assignment results. National output is concerned by the matchmaker. Economic growth is one of the primary jobs for government since economic reform was started. At the same time, especially after late 1990s, matchmaker also considers the development balance among regions. Since large regional disparity reduces social stability and long-run economic growth, to achieve balanced economic growth is one of the main policy considerations (Démurger, 2001; Xu, 2010). Economic development balance among regions could increase the motive power for the economic growth and improve the national ability of risk defense. Hence, the case is that both national output and regional balance are concerned in central objective.

Suppose $\gamma \in [0,1]$,the objective function of the matchmaker at t is,

$$V_t = \underset{(A,Y_{t-1}^i)}{Max} [\gamma \sum_{i=1}^{N} Y_t^i - (1-\gamma) \sum_{i=1}^{N} (Y_t^i - \overline{Y}_t)^2] \tag{4}$$

V_t measures the total value for the objective function at time t. The optimal value could be achieved by choosing appropriate leader with ability A to corresponding province with development level, Y_{t-1}^i. $\overline{Y}_t$ is the average output level for all regions at time t. The first part of the objective stands for largest national output and the second part stands for reducing regional disparity. γ measures the relative weight for economic growth and regional disparity. The objective value V is monotonically increasing in γ,

$$\frac{\partial V}{\partial \gamma} > 0$$

If γ is 1, only national output matters. Positive assortative matching would be implemented to achieve the largest total output given the complementarities between leader's ability and provincial economic development level. If γ is 0, then the objective is to minimize regional disparity. Negative assortative matching between leaders and provinces will be implemented. If γ is between 0 and 1, the assignment will be uncertain, and we will explain it in several cases.

Proposition 1 *If $\gamma = 1$, positive assortative matching would be implemented to achieve the optimal value. If $\gamma = 0$, negative assortative matching will be implemented. If γ is between 0 and 1, the assignment is uncertain depending on the amount of γ.*

Proof. We have obtained that it is complementary between leader's ability A and previous output level Y_{t-1}^i.

$$\frac{\partial^2 Y_t^i}{\partial A \partial Y_{t-1}^i} > 0 \tag{5}$$

will decrease, and this drives the wage inequality, and even the income inequality. The degree of sorting between spouses is exogenously given in the analysis of Fernandez and Rogerson (2001) (Fernandez et al, 2005). However, Fernandez et al (2005) assume both sorting and inequality are endogenous, and they find that it is significant and positive relationship between the degree of marital sorting and the wage inequality.

[24]The matchmaker is Central Committee of the Communist Party, who controls the political turnovers and rotations of officials within the centralized structure of personnel control (Huang, 1996; Li and Zhou, 2005).

To simplify the expression, we use the production function $Y = f(A, y)$, where $Y = Y_t^i$, $y = Y_{t-1}^i$. We firstly analyze two extreme cases, $\gamma = 1$, and $\gamma = 0$. Then we discuss the case when γ is between 0 and 1.

(1) $\gamma = 1$

The problem in equation (4) turns to be,

$$V = Max \sum_{i=1}^{N} Y_t^i$$

Firstly, according to Becker (1973), suppose $A_1 < A_2 < ... < A_n$, $y_1 < y_2 < ... < y_n$, for all i, $(i_1, i_2, ..., i_n) \neq (1, 2, ...n)$, we have the following result.

$$\sum_{j=1}^{n} f(A_j, y_{i_j}) < \sum_{i=1}^{n} f(A_i, y_i)$$

To prove this, we assume the contrary case that there is a permutation not satisfying $i_1 < i_2 < ... < i_n$. There is at least one i_{j_m} satisfying $i_{j_m} > i_{j_{m+1}}$, we could obtained that,

$$f(A_{j_m}, y_{i_{j_m}}) + f(A_{j_{m+1}}, y_{i_{j_{m+1}}}) > f(A_{j_m}, y_{i_{j_{m+1}}}) + f(A_{j_{m+1}}, y_{i_{j_m}}) \tag{6}$$

However, equation (6) is not consistent with the complementarities between A and y. So that positive assortative matching could generate the largest output is proved. Therefore, when $\gamma = 1$, positive assortative matching is implemented.

Next, we prove that negative assortative matching could generate the smallest output when $\gamma = 1$. Similarly, suppose $A_1 < A_2 < ... < A_n, y_1 < y_2 < ... < y_n$, for all i, $(i_1, i_2, ..., i_n) \neq (n, n-1, ..., 1)$, we have the following result.

$$\sum_{j=1}^{n} f(A_j, y_{i_j}) > \sum_{i=1}^{n} f(A_i, y_{n+1-i})$$

To prove this, we assume the contrary case that there is a permutation not satisfying $i_n < i_{n-1} < ... < i_1$, so at least there is i_{j_m}, and $i_{j_m} < i_{j_{m+1}}$.Now we have,

$$f(A_{j_{m+1}}, y_{i_{jm+1}}) + f(A_{j_m}, y_{i_{jm}}) < f(A_{j_{m+1}}, y_{i_{jm}}) + f(A_{j_m}, y_{i_{jm+1}})$$

However, the above equation is not satisfying the complementarities between A and y because $i_{j_m} < i_{j_{m+1}}$, so negative assortative matching could generate the smallest output.

(2) $\gamma = 0$

The problem in equation (4) turns to be the following expressions,

$$V = Max[-\sum_{i=1}^{N} (Y_t^i - \overline{Y}_t)^2]$$

Suppose $A_1 < A_2 < ... < A_n$, $y_1 < y_2 < ... < y_n$, for all i, $(i_1, i_2, ..., i_n) \neq (n, n-1, ..., 1)$,

$$-\sum_{j=1}^{n}[f(A_j, y_{i_j}) - \frac{\sum_{j=1}^{n} f(A_j, y_{i_j})}{N}]^2 < -\sum_{i=1}^{n}[f(A_i, y_{n+1-i}) - \frac{\sum_{i=1}^{n} f(A_i, y_{n+1-i})}{N}]^2$$

The above equation reflects that negative assortative matching could generate the optimal output.

To prove it, we assume the contrary case that the permutation is not satisfying $i_n < i_{n-1} < ... < i_1$, so at least there is i_{j_m}, and $i_{j_m} < i_{j_{m+1}}$. Now we have,

$$\begin{aligned} & -\{[f(A_{j_m}, y_{i_{j_m}}) - \frac{f(A_{j_m}, y_{i_{j_m}}) + f(A_{j_{m+1}}, y_{i_{j_{m+1}}})}{2}]^2 \\ & +[f(A_{j_{m+1}}, y_{i_{j_{m+1}}}) - \frac{f(A_{j_m}, y_{i_{j_m}}) + f(A_{j_{m+1}}, y_{i_{j_{m+1}}})}{2}]^2\} \\ > \quad & -\{[f(A_{j_m}, y_{i_{j_{m+1}}}) - \frac{f(A_{j_m}, y_{i_{j_{m+1}}}) + f(A_{j_{m+1}}, y_{i_{j_m}})}{2}]^2 \\ & +[f(A_{j_{m+1}}, y_{i_{j_m}}) - \frac{f(A_{j_m}, y_{i_{j_{m+1}}}) + f(A_{j_{m+1}}, y_{i_{j_m}})}{2}]^2\} \end{aligned}$$

Reorganizing this equation, we have,

$$[f(A_{j_{m+1}}, y_{i_{j_{m+1}}}) - f(A_{j_m}, y_{i_{j_m}})]^2 < [f(A_{j_m}, y_{i_{j_{m+1}}}) - f(A_{j_{m+1}}, y_{i_{j_m}})]^2$$

The left hand side is larger than 0, and term inside the bracket in right hand side is uncertain. There are two cases,

(1) If $f(A_{j_m}, y_{i_{j_{m+1}}}) > f(A_{j_{m+1}}, y_{i_{j_m}})$

We simplify the expression and reorganize it,

$$f(A_{j_{m+1}}, y_{i_{j_{m+1}}}) - f(A_{j_m}, y_{i_{j_{m+1}}}) < f(A_{j_m}, y_{i_{j_m}}) - f(A_{j_{m+1}}, y_{i_{j_m}})$$

(2) If $f(A_{j_m}, y_{i_{j_{m+1}}}) < f(A_{j_{m+1}}, y_{i_{j_m}})$

We simplify the expression and reorganize it,

$$f(A_{j_{m+1}}, y_{i_{j_{m+1}}}) - f(A_{j_{m+1}}, y_{i_{j_m}}) < f(A_{j_m}, y_{i_{j_m}}) - f(A_{j_m}, y_{i_{j_{m+1}}})$$

Obviously, the above two equations are not satisfied, because the left hand side is positive while the right hand side is negative. Therefore, we claim that,

Claim 1 *Negative assortative matching achieves the optimal value when $\gamma = 0$.*

Next, we prove that positive assortative matching could generate the smallest value when $\gamma = 0$.

Suppose, $A_1 < A_2 < ... < A_n, y_1 < y_2 < ... < y_n$, for all i, $(i_1, i_2, ..., i_n) \neq (1, 2, ...n)$, we have

the following result.

$$-\sum_{j=1}^{n}[f(A_j, y_{i_j}) - \frac{\sum_{j=1}^{n} f(A_j, y_{i_j})}{N}]^2 > -\sum_{i=1}^{n}[f(A_i, y_i) - \frac{\sum_{i=1}^{n} f(A_i, y_i)}{N}]^2$$

To prove this, we assume the contrary case that there is a permutation not satisfying $i_1 < i_2 < ... < i_n$. There is at least one i_{j_m} satisfying $i_{j_m} > i_{j_{m+1}}$, we could obtained that,

$$\begin{aligned} & -\{[f(A_{j_{m+1}}, y_{i_{j_{m+1}}}) - \frac{f(A_{j_{m+1}}, y_{i_{j_{m+1}}}) + f(A_{j_m}, y_{i_{j_m}})}{2}]^2 \\ & +[f(A_{j_m}, y_{i_{j_m}}) - \frac{f(A_{j_{m+1}}, y_{i_{j_{m+1}}}) + f(A_{j_m}, y_{i_{j_m}})}{2}]^2\} \\ < \quad & -\{[f(A_{j_{m+1}}, y_{i_{j_m}}) - \frac{f(A_{j_{m+1}}, y_{i_{j_m}}) + f(A_{j_m}, y_{i_{j_{m+1}}})}{2}]^2 \\ & +[f(A_{j_m}, y_{i_{j_{m+1}}}) - \frac{f(A_{j_{m+1}}, y_{i_{j_m}}) + f(A_{j_m}, y_{i_{j_{m+1}}})}{2}]^2\} \end{aligned}$$

Reorganizing the above equation, we have

$$[f(A_{j_{m+1}}, y_{i_{j_m}}) - f(A_{j_m}, y_{i_{j_{m+1}}})]^2 < [f(A_{j_{m+1}}, y_{i_{j_{m+1}}}) - f(A_{j_m}, y_{i_{j_m}})]^2$$

The left hand side is larger than 0. There are two cases in the right hand side,
(1) If $f(A_{j_{m+1}}, y_{i_{j_{m+1}}}) > f(A_{j_m}, y_{i_{j_m}})$
We simplify the expression and reorganize it,

$$f(A_{j_{m+1}}, y_{i_{j_m}}) - f(A_{j_{m+1}}, y_{i_{j_{m+1}}}) < f(A_{j_m}, y_{i_{j_{m+1}}}) - f(A_{j_m}, y_{i_{j_m}})$$

The left hand is larger than 0, and the right hand side is less than 0.
(2) If $f(A_{j_{m+1}}, y_{i_{j_{m+1}}}) < f(A_{j_m}, y_{i_{j_m}})$

$$f(A_{j_{m+1}}, y_{i_{j_m}}) - f(A_{j_m}, y_{i_{j_m}}) < f(A_{j_m}, y_{i_{j_{m+1}}}) - f(A_{j_{m+1}}, y_{i_{j_m}})$$

The left hand is larger than 0, and the right hand side is less than 0.
Therefore we claim that,

Claim 2 *Positive assortative matching generates the smallest value when* $\gamma = 0$.

Hence, any deviation from $V^p_{\gamma=0}$ (the value generated by positive assortative matching if $\gamma = 0$) in figure 4 could increase the value V. The values generated by mixed matching and negative assortative matching are always larger than the value generated by positive assortative matching when $\gamma = 0$.

(3) γ is between 0 and 1

When γ is changing between 0 and 1, there are two critical values γ^* and γ^{**}. When there are various types of matching, $\gamma^{**}_{m_i}$ is corresponding to the cross point between positive assortative

matching and mixed matching, for example type m_i. Mixed matching is the type of matching which is not positive assortative matching or negative assortative matching.

$$V^p(\gamma) = V^{m_i}(\gamma)$$

Solving this equation, we could obtain, $\gamma^{**}_{m_i}$. And γ^{**} is the largest among all $\gamma^{**}_{m_i}$.

$$\gamma^{**} = \max(\gamma^{**}_{m_i})$$

$\gamma^{*}_{m_j}$ is representing the cross point between negative assortative matching and mixed matching, for example type m_j,

$$V^N(\gamma) = V^{m_j}(\gamma)$$

Solving this equation, we could obtain, $\gamma^{*}_{m_j}$. And γ^{*} is the smallest γ among all $\gamma^{*}_{m_j}$.

$$\gamma^{*} = \min(\gamma^{*}_{m_j})$$

γ^{**} and γ^{*} could be equal or unequal. When $\gamma = 0$, negative assortative matching generates the largest value, and positive assortative matching generates the smallest value. Value generated by any type of mixed matching is between the maximum and minimum value when $\gamma = 0$. Similarly, when $\gamma = 1$, value generated by any type of mixed matching is also between the maximum and minimum values generated by positive and negative assortative matching. We do not know the specific value for any type of mixed matching. The cases of $\gamma^{*} < \gamma^{**}$ and $\gamma^{*} \geq \gamma^{**}$ are both possible. We explain them in figure 4 and 5, and generate the sufficient conditions for each case.

In figure 4, the horizontal axis is γ, and the vertical axis is V. $V^{M1}_{\gamma=0}V^{M1}_{\gamma=1}$ and $V^{M2}_{\gamma=0}V^{M2}_{\gamma=1}$ reflect the changes of V when γ changes given the types of mixed matching M_1 and M_2. Given one type of mixed matching, M_1, the value when $\gamma = 0$ is $V^{M1}_{\gamma=0}$, and the value when $\gamma = 1$ is $V^{M1}_{\gamma=1}$. The cross point between value line of positive assortative matching and negative assortative matching is Q. If we connect $V^{M1}_{\gamma=0}$ and Q, this line will generate a value Y when $\gamma = 1$. Similarly, for another type of mixed matching, M_2, if we connect $V^{M2}_{\gamma=0}$ and Q, the line will generate a value X when $\gamma = 1$. The sufficient condition for $\gamma^{*} < \gamma^{**}$ is that the value generated by the type of mixed matching M_1 when $\gamma = 1$, $V^{M1}_{\gamma=1}$ is larger than value Y, and the value generated by another type of matching M_2 when $\gamma = 1$, $V^{M2}_{\gamma=1}$ is larger than X. Generally, the value of each type of mixed matching M_i when $\gamma = 1$, $V^{Mi}_{\gamma=1}$ should be larger than the corresponding value generated by the line $V^{Mi}_{\gamma=0}Q$ when $\gamma = 1$.

Accordingly, applying the same definition of X and Y by connecting $V^{M2}_{\gamma=0}Q$ and $V^{M1}_{\gamma=0}Q$ with the line of $\gamma = 1$ respectively in figure 5, we compare the real value of each type of mixed matching $V^{M2}_{\gamma=1}$ and $V^{M1}_{\gamma=1}$ with X and Y. The sufficient condition for $\gamma^{**} < \gamma^{*}$ is that real value generated by the type of mixed matching $V^{M1}_{\gamma=1}$ is below value Y, and the real value generated by another type of matching $V^{M2}_{\gamma=1}$ is smaller than X. Generally, when $\gamma = 1$, the real value of each type of mixed matching $M_i, V^{Mi}_{\gamma=1}$ should be smaller than the corresponding value generated by the line $V^{Mi}_{\gamma=0}Q$

when $\gamma = 1$.[25]

In figure 4 we explain the case of $\gamma^* < \gamma^{**}$. We will prove that when $\gamma \in (0, \gamma^*]$, negative assortative matching is implemented; when $\gamma \in [\gamma^{**}, 1)$ positive assortative matching is implemented. For illustration, we consider two types of mixed matching in figure 4.

To prove the existence of γ^{**}, we apply the Intermediate Value Theorem (IVT). (1) When $\gamma = 1$, positive assortative matching generates the largest output at point $V^p_{\gamma=1}$. All values generated by other matching results are below $V^p_{\gamma=1}$. (2) When $\gamma = 0$, value generated by positive assortative matching $V^p_{\gamma=0}$ is lower than the value generated by negative assortative matching, $V^N_{\gamma=0}$. Actually, when $\gamma = 0$, negative assortative matching generates the optimal value at point $V^N_{\gamma=0}$, and all values from other matching results are below $V^N_{\gamma=0}$. (3) The objective function is monotonic over γ, $\frac{\partial V}{\partial \gamma} > 0$. Applying IVT in figure 4, there will be a cross point D generated between positive assortative value $V^p_{\gamma=0}V^p_{\gamma=1}$ and mixed matching value $V^{M2}_{\gamma=0}V^{M2}_{\gamma=1}$. Cross point E is generated by the positive assortative matching value and mixed matching value $V^{M1}_{\gamma=0}V^{M1}_{\gamma=1}$. γ^{**} is the larger γ related to point E. Obviously, when $\gamma \geq \gamma^{**}$, positive assortative matching could generate the maximum value.

Notice that $V^p_{\gamma=0}V^p_{\gamma=1}$ is the value V for positive assortative matching when γ changes. Given that it is positive matching, $\sum_{i=1}^{N}(Y^i_t - \overline{Y}_t)^2$ and $\sum_{i=1}^{N} Y^i_t$ will be given, and then $V^p_{\gamma=0}V^p_{\gamma=1}$ is only affected by the parameter γ. $V^p_{\gamma=0}V^p_{\gamma=1}$ in figure 4 reflects the changes of value when γ is changing. Obviously, it is linear and increasing with γ. And $V^N_{\gamma=0}V^N_{\gamma=1}$ is the value V when γ is changing given that it is negative assortative matching. They are also linear and increasing with γ.

To prove the existence of γ^*, applying IVT in figure 4: (1) When $\gamma = 0$, negative assortative matching generates the optimal value. (2) When $\gamma = 1$, value generated by negative assortative matching is smaller than positive assortative matching. (3) The objective function is monotonic, $\frac{\partial V}{\partial \gamma} > 0$. There will be a cross point A between the negative assortative matching value $V^N_{\gamma=0}V^N_{\gamma=1}$ and mixed matching value $V^{M2}_{\gamma=0}V^{M2}_{\gamma=1}$, and a cross point at B between negative assortative matching and mixed matching $V^{M1}_{\gamma=0}V^{M1}_{\gamma=1}$. γ^* is the smaller γ related to point A. So when $\gamma \leq \gamma^*$, negative assortative matching could generate the largest value.

When $\gamma^* < \gamma < \gamma^{**}$, mixed matching generates the largest output. Different combination of mixed matching could generate the largest values when γ is different. In figure 4, the value of AC in the mixed matching value $V^{M2}_{\gamma=0}V^{M2}_{\gamma=1}$ is highest when $\gamma^* < \gamma \leq \gamma^M$, γ^M is the cross point between the two types of mixed matching. And value of CE in the mixed matching value $V^{M1}_{\gamma=0}V^{M1}_{\gamma=1}$ is the largest γ when $\gamma^M < \gamma < \gamma^{**}$.

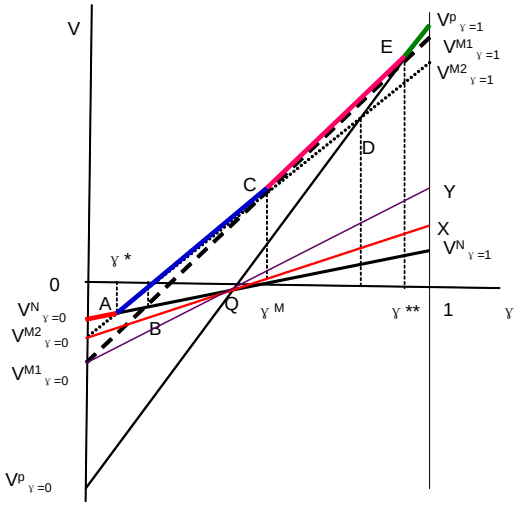
Therefore, the total value V is increasing with γ, and in a nonlinear way which incorporate the optimal value for different types of matching. In figure 4, the optimal value is the dark line which connect the highest value for each type of matching $V^N_{\gamma=0}A, AC, CE, EV^p_{\gamma=1}$.[26] We claim that,

Claim 3 *If $\gamma^* < \gamma^{**}$, when $\gamma \geq \gamma^{**}$, central authority as a matchmaker will implement positive as-*

[25] Because of the symmetry of $\gamma = 1$ and $\gamma = 0$, the sufficient conditions could also be changed to see whether the value is above or below the critical point (similar definition of X and Y when $\gamma = 0$) when $\gamma = 0$ given any type of mixed matching.

[26] Figure 4 shows the simplest case. There could be many various types of matching outcomes depending on the numbers in the two sides of matching market; however, the analysis does not change.

Figure 4 Optimal matching when γ is between 0 and 1 given $\gamma^* < \gamma^{**}$



sortative matching. When $\gamma \leq \gamma^*$, central authority will implement negative assortative matching. If $\gamma^* < \gamma < \gamma^{**}$, the assignment will be mixed matching.

We explain the case $\gamma^{**} < \gamma^*$ in figure 5. The existence of γ^{**} and γ^* could be proved similarly. In this case, all values corresponding to mixed matching are dominated by positive assortative matching and negative assortative matching. The cross point between positive assortative matching and negative assortative matching Q is realized when $\gamma = \gamma_o$. (1) When γ is between 0 and γ_o, negative assortative matching generates the largest value. (2) When γ is between γ_o and 1, positive assortative matching generates the largest value. The dark line composed by $V^N_{\gamma=0}Q$ and $QV^p_{\gamma=1}$ in figure 5 plots the maximum V. Figure 5 reflects the simple case when there are two types of mixed matching, and it is natural extension to the case with more types of mixed matching, and mixed matching will not generate the optimal value in this case.

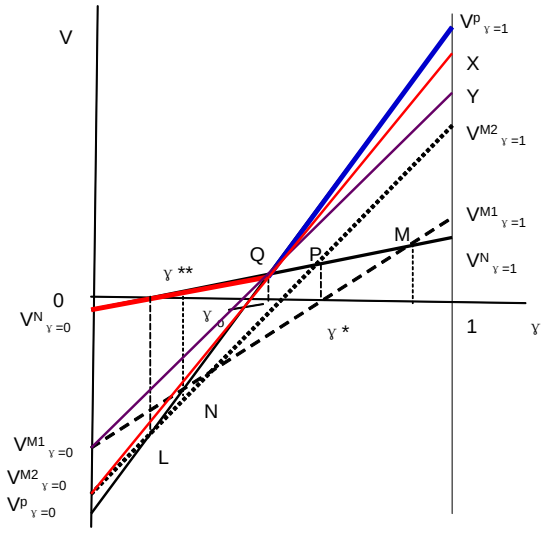
Claim 4 *If $\gamma^{**} < \gamma^*$, negative assortative matching or positive assortative matching will generate the largest value depending on the amount of γ.*

Finally, if $\gamma^{**} = \gamma^*$, mixed matching has the cross point Q with positive assortative matching, and mixed matching has the same cross point Q with negative assortative matching. The dark line composed by the line $V^N_{\gamma=0}Q$ and $QV^p_{\gamma=1}$ in figure 5 still plots the maximum V.

In summary, positive assortative matching could generate the largest value when $\gamma = 1$, and negative assortative matching could generate the most desired output $\gamma = 0$. When γ is between these two extreme cases, the matching types are uncertain. ■

As a result, positive assortative matching is implemented when central authority concentrates on largest national output. And negative assortative matching between leaders and provinces is

Figure 5 Optimal matching when γ is between 0 and 1 given $\gamma^{**} < \gamma^{*}$



made when central authority concerns more in reducing regional disparity.[27].

4 Empirical method

4.1 Measures for the two sides of matching

In the empirical analysis, we will identify that how leaders with different abilities are allocated to each province. And the assignment result could be discovered from the relationship between Y^i_{t-1} and A. Y^i_{t-1} could be easily obtained from the data. In the first place, we calculate A.

Economic performance in each province reflects the provincial leader's ability in developing economy. We use TFP growth rate in province j to measure the leader's ability.[28] TFP is the part in the production that is not explained by inputs, and it reflects the efficiency of production.[29] This efficiency is closely related to provincial leaders. The economic reform since 1978 increases the autonomy of provincial governments (Qian and Xu, 1993). The role of leaders and the quality of provincial leadership could be reflected through economic performance in each province. The economic strategies and policies are closely related to local leaders, and differences in strategies among provinces could induce larger differences in development[30]. Tan (2002) proves that the

[27] In reality, large regional inequality has induced less developed regional government to give policy responses in increasing infrastructure investment to catch up with the more developed regions (Démurger et al, 2002).

[28] Hermanlin and Weisbach (1998) argue that firm's performance is one signal of CEO's ability.

[29] TFP represents the remaining term that is not counted by physical capital and human capital. For example, it could include technical progress, failure of the assumption of constant return to scale, changes in production efficiency, and other factors (Li, 2009).

[30] Tan (2002) compares the development strategy in Fujian and Jiangxi. He proves the importance of leaders in improving local economy by adopting coherent strategies towards provincial economy.

growth difference between provinces, especially the provincial disparity is a function of provincial leader's role. The abilities of regional leaders are important in improving regional economy (See Tan, 2002). The provincial TFP differences in economy are related to variations in provincial physical technology, which is related to policies and strategies in technology development implemented by local governments[31].

Next, we give an introduction to the calculation of TFP. Suppose one neoclassical production function,

$$Y = F(A, K, L)$$

where Y is the total production, L is labor input, and K is capital input. A measures the technology improvement. The growth rate of production could be divided into several parts based on the inputs and technological progress. To generate specific expressions, following Barro (1999) and Li (2009), we use Cobb-Douglas production function to generate TFP[32].

$$Y = AK^{\alpha}L^{\beta}$$

Where, $\alpha > 0$, $\beta > 0$. Taking logarithmic form and make first difference to the production function, TFP growth rate $TFP_{t-1,t}$ could be obtained,

$$TFP_{t-1,t} = \ln(\frac{Y_t}{Y_{t-1}}) - \alpha \ln(\frac{K_t}{K_{t-1}}) - \beta \ln(\frac{L_t}{L_{t-1}}) \tag{7}$$

Under the assumption of perfect competition and constant returns to scale of capital, α and β are the shares of capital and labor in the total output. The calculation of TFP is to implement equation (7), and it does not involve econometric estimation (Barro, 1999). The regression analysis could also be used to obtain TFP by regressing output growth on the growth rates of labor and capital, and the intercept could be used to measure TFP. The regression analysis does not require the assumption that a marginal product of input is coinciding with the input price, but it has several disadvantages (Barro, 1999). Firstly, the input growth rates are not exogenous with respect to TFP growth rate. Secondly, if the measure of input growth is measured with error, the regression could not generate consistent estimator. As a result, we apply the non econometric calculation to obtain TFP[33].

Literatures have used different measures for capital and labor (Jorgenson, 1967; Young, 1995). The capital stock is estimated using the perpetual inventory method with geometric depreciation (Holz, 2006) in this paper. All fixed capital investment is transferred into the real capital based on the constant price of 1990. Capital stock is calculated based this equation,

$$K_t = \frac{I_t}{P_t} + (1 - \delta)K_{t-1}$$

[31] Hall and Jones (1999) proved that the income differences among countries are due to differences in TFP and the differences in TFP are related to the variations in physical technology.

[32] The translogarithmic function form could also be used as the production function (Young, 1995) to obtain TFP.

[33] Other methods have also been used to get TFP. For example, the dual approach (Barro, 1999), which is the Solow residual obtained from the growth rate of input prices instead of the growth of the amount of inputs.

I_t is the fixed capital investment at time t, P_t is the investment index at time t[34], δ is the depreciation rate.[35] The depreciation rate is 0.04 for 1978-1992, 0.05 for 1993-2008 (Islam and Dai, 2007). We take capital investment as a whole rather than dividing them into different groups because of the data limitation.

Labor input is number of working population in rural areas and urban areas in each province. It is calculated by the total population multiplying the proportion of working population between 15 and 64 to total population in 2000, which is based on the population survey in 2000. In order to avoid overestimation, we consider the quality of different labors based on the average years of education[36] (Barro, 1999). H_t measures the human capital, then the TFP calculation turns to be,

$$TFP_{t-1,t} = \ln(\frac{Y_t}{Y_{t-1}}) - \alpha \ln(\frac{K_t}{K_{t-1}}) - \beta[\ln(\frac{L_t}{L_{t-1}}) + \ln(\frac{H_t}{H_{t-1}})] \tag{8}$$

β is the total nominal labor compensation in rural areas and urban areas divided by nominal GDP of each year (Li, 2009), and α is one minus β.[37] The average share of labor input is about 42% from 1978 to 2008 for all the provinces[38]. After calculation, we find that the average TFP growth rate between 1985 and 2008 is 4.79%. This is similar with Li (2009) who obtains an average of 4.65% between 1984 and 2006. Islam, Dai and Sakamoto (2006) have found the TFP growth rate is between 2.95% and 4.06% with different methods in China from 1978 to 2002. In Hu and Khan (1997), they find that the TFP growth rate between 1979 and 1994 is 3.9%. Chow and Li (2002) shows that the TFP growth rate is 2.6% from 1978 to 1998. This is slightly higher than other studies, and this might be due to the longer time periods which include the more recent years, and the output growth is higher in more recent years (See Li, 2009). The calculated TFP growth rate from 1985 to 2008 is shown in table A3.

We use the average TFP growth rate during the tenure of each leader, $TFP_{average}$ to measure of the unobserved ability of provincial leaders in improving economy. TFP_t is the annual TFP

[34] The price index for investment comes for the statistical yearbook for the time period 1991-2008. For the period before 1991, it comes from "The Gross Domestic Product of China, 1952-1995". There is no record for the investment index in Tibet. The fixed-base index is based on the constant price of 1990. Then the year-based chain index of 1991 is also transferred to the fixed-base index. The fixed-base index of 1992 is to multiply the year-based chain index of 1991 and 1992. Similar calculation is applied to all others years.

[35] Suppose that the initial year of capital stock K_0 is 1957,

$$K_0 = I_0/(g_0 + \delta_0)$$

Where I_0 is the investment for the initial year, δ_0 is the depreciation rate in the initial year, which is 0.03 before 1978. g_0 is the growth rate for capital around initial year. We usually take the average growth rate for four or five years around the initial year. Because of the data limitation, if there is no statistics in 1957, we use the first year that is recorded in the statistics. For example, the first year for Chongqing in the statistics is 1997.

[36] We thank Kui-Wai Li for sharing the data of human capital. The data is from http://fbstaff.cityu.edu.hk/efkwli/ChinaData.html. There are four education levels. It is 5 years for primary education, 8 years for junior secondary education, 11 years for senior education and specialized secondary education, and 14.5 years for higher education. The human capital in each year is calculated, $E_t = \frac{(5E_{t1}+8E_{t2}+11E_{t3}+14.5E_{t4})}{\text{number of working population at time t}}$

Where, E_{ti} is the number of years for each education level i at time t.

[37] We do not use the average wage level and the number of employees to calculate the labor compensation. Because in the yearbook, wage statistics is confined in urban areas, and this underestimates the proportion of labor inputs in GDP. Instead, we use the average labor income in rural and urban areas and the number of employees.

[38] α is 0.52, and β is 0.48 in Li (2009).

growth rate at time t.

$$TFP_{average} = \frac{\sum_{t=1}^{T} TFP_t}{T} \tag{9}$$

T is the number of years that leaders have been in the current post until the considered year. For example, if the leader has been a governor or secretary for one year, $T = 1$; after another year, $T = 2$ and so on. Average performance over the tenure is less noisy and puts weight on the average term instead of short term shocks.

To identify central assignment over provincial leaders, we confine our analysis to leaders who are rotated among provinces (Xu et al, 2007). If the leader has not been rotated among provinces, it is difficult to obtain her ability in developing economy for several reasons. Firstly, if one leader is rotated from central department to province, because of the special and single function of each central department, it is difficult to get her ability. Secondly, if one leader rotated from vice leader in one province to chief leader in another province, it is difficulty to get her ability. There are more than one vice leaders (vice secretary, vice governor) in each province and vice leaders have different responsibilities over the provincial affairs. Thirdly, if one leader continue to stay in one province for the second term, then the TFP growth rate in the previous term and Y_{t-1}^i are closely related and multicollinearity problem exists. The correlation coefficient between the two could not reflect the mode of assignment.

To look at the rotated provincial leaders, suppose one leader who used to work in province j at time $t-1$, she was rotated to province i ($j \neq i$) at time t. Leader's ability is reflected from TFP growth rate in the previous province j, $TFP_{average}^j$. All the rotated provincial leaders are working under the same incentive frameworks and same institutions, therefore we could use TFP to represent one's ability.

The calculated $TFP_{average}^j$ might be affected by endowment in province j, E^j. At the same time, Y_{t-1}^i is generated based on endowment E^i. However, because endowment E^j and E^i are not related, and it is impossible for one leader to impose her effect on the region that she has never been, there is no endogeneity problem. The relationship between $TFP_{average}^j$ and Y_{t-1}^i could tell us the result of assignment between provincial leaders and provinces.[39]

Finally, we have to admit that when central authority makes the decision of rotation from j to i, both the effects of E^j and E^i are considered. So the correlation between E^j and E^i might not be 0. In addition, when making investment of important projects, central authority would consider the endowment of each province based on national planning and management, and this also reflects potential relationship among endowments of each province. This underlying relationship between the endowment E^j and E^i could not be alleviated within our framework. Besides, provincial leaders have other ways of turnovers besides rotation, for example, promotion to central department of higher level. These leaders who are promoted to higher level might be more capable than the leaders who are rotated (Li and Zhou, 2005), so there might be some selection biases.

[39] If one leader has been rotated more than once, we could still obtain her ability by drawing the average TFP growth rate over the tenure in the previous province before rotation.

4.2 Test of matching

In this part, we explore ways to test the matching between leader's ability and the economic development level in each province. We use traditional correlation coefficient, Spearman rank correlation coefficients and regression coefficients between $TFP^j_{average}$ and Y^i_{t-1} to measure the mode of central assignment (Fernández et al, 2005; Mendes et al, 2007). In addition, the measure derived by Liu and Lu (2006) is also used to look at the degree of matching between leaders and provinces

Different methods are applied in previous literatures to test assortative matching, for example, between workers and firms. Mendes et al (2007) summarize three measures of testing assortative matching. Firstly, the traditional correlation coefficient between firm-specific productivity and the time average of the proportion of people who have higher education. Secondly, the rank correlation coefficient between the two sides, and this could mitigate the effects of extreme value on the correlation coefficients. Thirdly, the regression coefficient between the two sides is used. In marriage market, Mare (1991), Kremer (1997) and Fernandez et al (2005) look at the correlation of education level between spouses to find the mode and degree of mating. Fernandez and Rogers (2001) use the proportion of marriages with positive assortative matching to measure the degree of assortative matching.

Correlation coefficients, Spearman rank correlation coefficients and regression coefficients are applied in our analysis. Correlation coefficient indicates both the direction and degree of correlation of variables. It varies from -1 to 1. Larger positive correlation coefficients reflect that the positive assortative matching is stronger (Mendes et al, 2007). Correlation is different from causality, because it only reflects the association of variables in the two sides. We don't give any judgment of dependent or independent variables. Spearman correlation reflects the correlation coefficients between the two sides of ranked variables. The direction of correlation is shown by the sign of Spearman correlation coefficients between variables. When there are no prominent outliers, these two correlation coefficients are similar. Spearman correlation coefficient has several advantages. Firstly, it is less sensitive to the outliers than correlations, because the variables have been transferred to ranks. Spearman correlations could be 1 if the variables are monotonically related, when the correlation coefficient is not 1. Secondly, Spearman correlation does not require that the variables in the two sides should be linearly related, and it does not impose any assumptions of the distribution of the variables. It applies to variables which are difficult to measure.

In addition, Liu and Lu (2006) propose one new measure for the degree of sorting based on the trait taking the value of (0,1) by dividing traits (education level of each man and woman) into high and low types. It is 1 if one has a post secondary education or above, 0 otherwise. They use the relative distance of actual matching outcome to the perfectly random matching outcome to measure the degree of sorting. They argue that the ordinary correlation coefficient could be affected by both the degree of assortative matching and the distribution of traits on the two sides of matching, and it is difficult to identify whether changes in correlation coefficients is caused by variations of matching or changes in the distribution of traits. And their measure could mitigate this problem by truly showing the degree of matching. In this paper, we built one measure for the

degree of matching between leaders and provinces similar as theirs.

We use the median value to divide leaders' abilities and provincial economies during each time period we are considering. Leader's ability which is larger than the median value is 1, otherwise 0. It is 1 if provincial GDP per capita level which is larger than the median value, otherwise 0. There are N leaders and N provinces in the two sides. There could be four types of matching result $(i,\ j)$, $i = 0, 1,\ j = 0, 1$. i and j are representing the types of leaders and provinces based on their abilities and GDP level. N_1^A is the number of leaders who have higher abilities than median value, and N_1^y are the number of provinces whose GDP per capita level is higher than median amount. (1,1) and (0,0) are positive assortative matching results, and (1,0) and (0,1) are negative assortative matching results. For example, $N_{1,1}$ is the number of matching result with type $(1, 1)$. According to Liu and Lu (2006), we define the relative distance between assortative matching result and perfectly random matching result as P,

$$P = \begin{cases} \frac{N_{1,1} - Q^-}{\min(N_1^A, N_1^y) - Q^-}, \text{ if } N_{1,1} \geq Q \\ \frac{Q^+ - N_{1,1}}{Q^+ - \max(0, N_1^A - N_1^y)}, \text{ if } N_{1,1} < Q \end{cases}$$

In this equation, $Q = \frac{N_1^A N_1^y}{N}$. Q^- is the biggest integer that is less than Q or it could be equal to Q. Q^+ is the smallest integer that is bigger than Q or it could be equal to Q.

The sign for assortative matching is represented by,

$$R = \begin{cases} P, \text{ if } N_{1,1} \geq Q \\ -P, \text{ if } N_{1,1} < Q \end{cases} \tag{10}$$

This measure will be used to test the degree of assortative matching. Different measures in different time periods could reflect the change in R. Liu and Lu (2006) proves this could generate consistent result with traditional measures of assortative matching, the correlation coefficients between the two sides of matching (Kremer, 1997) and the proportion of matching with the same trait. This degree of assortative matching could accommodate the changes in traits distribution. Finally, note that we do not have an objective standard to divide the level of leader's ability as high and low, therefore this might induce some inconsistencies between this measure and the correlation coefficients. In addition, the degree of matching is built on one dichotomous trait (education) on the two sides of matching. While in our case, there are two traits on the two sides.

5 Data

The data used in this paper covers the provincial leaders in 31 provinces in China from 1993 to 2008. We focus on the time period after socialist economy was officially adopted in 1992. It is considered as the end point of transition when building one socialist market economy was raised in 1992 (See Naughton, 2008). The information of provincial leaders comes from one book published in Chinese "*The Documentation of Administration in the People's Republic of China* (2003)", and the website "*http://www.xinhuanet.com/*". These data sets provide detailed information of

leaders, for example, the age, gender, education, past working experiences, date of joining the Party. More importantly, they track down the date of taking and leaving office in each province, and the following arrangement for each leader, which includes promotion, termination, lateral move or other arrangement. The data of economic performance for each province from 1992 to 2008 comes from the statistical yearbook, and "*The gross domestic product of China, 1952-1995*" for data from 1978 to 1991. We use GDP deflator to transfer all GDP per capita into real GDP per capita based on the constant price in 1990.

Some leaders might hold two positions at the same time, for example governor and vice secretary. We take the higher position which reflects the true power of the leader. In total, there are 344 chief provincial leaders since 1978. From 1993 to 2008, there are 198 chief leaders and 1184 leader-year observations. In table 1, we list the general statistics about the variables that we are interested.

The rotated leaders include both provincial governors and provincial secretaries. In this sub sample, most people are rotated among provinces only once and a few leaders have been rotated for twice or three times. After identifying destinations and origins of these rotated leaders, there are 64 leaders who worked in different provinces before and after rotation since 1978, and 292 provincial leader-year observations. It turns to be 41 rotated leaders from 1993 to 2008. The rotation before 1993 is only a few.[40] Generally, provincial governor and party secretary do not change at the same time to keep the stability of leadership in the original province. As a result, the number of rotations is not many in each year.

In table 2, we compare the number of rotations for leaders in each province from 1993 to 2008. Hebei is the province which has the largest number of rotations, 6 times. Liaoning and Qinghai are the second largest provinces of rotations, 5 times. While Xinjiang has only one rotation during the time period from 1993 to 2008[41].

The rotation includes two directions—flowing in and flowing out. Generally, Hebei has the largest number of leaders flowing in, 4 times. Guangdong, Henan, Liaoning and Beijing are the second largest provinces, 3 times. Instead, Guangxi, Hainan, Guizhou, Xinjiang and Qinghai do not have leaders flowing in.[42] For the number of leaders who are rotated from one province to other provinces, Qinghai, Gansu and Henan ranks first with 4 times.[43] Xinjiang, Inner Mongolia, Tianjin, Heilongjiang, Shanghai, Sichuan, Yunnan and Guangdong do not have leaders flowing out

[40] In 1990, there is formal regulation, which requires that leaders should be rotated among provinces or between provinces and central departments. "Central Committee of the Communist Party's Decision about Rotating Party Leaders and Government Leaders of China" was issued in 1990.

[41] Why different provinces involve different numbers of rotations is complex problem. The official reason of rotation is to prevent factionalism (Huang, 2002). Besides, rotation could reveal information to the successor and central authority, which is helpful to get complete assessment to this leader. Finally, the rotation could increase the working experiences and skills for provincial leaders.

[42] Most of these provinces are autonomous regions with different races, which need special experiences in management. Inside leader are more familiar with local affairs than outsiders who have been working in other provinces.

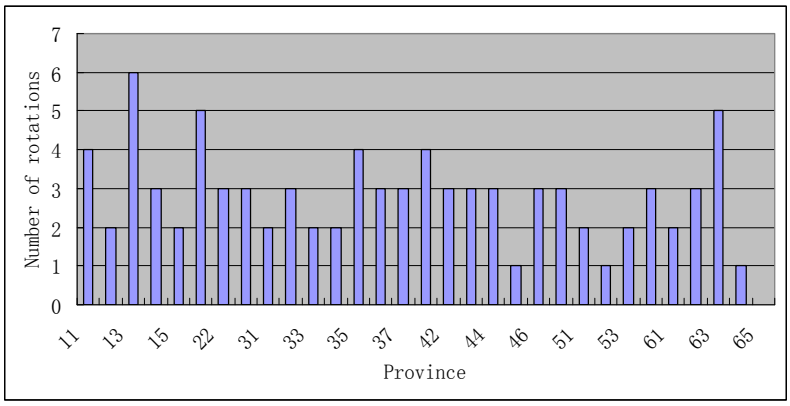
[43] All these three provinces are less developed provinces, and working in these provinces could increase the leader's ability and experiences in dealing problems in less developed regions.

Table 1 General statistics for the provincial leaders after 1993

Variable	Mean	Std. Dev	Min	Max	N
promotion	0.054	0.226	0	1	1184
termination	0.076	0.264	0	1	1184
Annual GDP growth rate	0.096	0.060	-0.223	0.467	1173
Average TFP growth rate over the tenure	0.049	0.039	-0.089	0.335	1152
Average GDP growth rate over the tenure	0.122	0.066	-0.07	0.772	1132
age	58.509	4.376	42	68	1179
age65	0.068	0.252	0	1	1184
education	0.825	0.380	0	1	1168
central	0.212	0.409	0	1	1184
SOE	0.027	0.162	0	1	1184
Years of Party	34.722	7.664	6	52	1167
Origin of Shanghai	0.025	0.157	0	1	1184
Communist Youth League	0.0870	0.282	0	1	1184
home	0.319	0.466	0	1	1184
tenure	3.215	2.650	0	15.833	1184

The observation unit is provincial leader-year. Promotion is 1 if one leader is promoted in one year, 0 otherwise. Termination is 1 if one leader is retired or demoted, 0 otherwise. Annual GDP growth rate is the GDP growth rate annually. Average TFP growth rate is the average TFP growth rate over the tenure. Average GDP growth rate over the tenure is the average GDP growth rate during the tenure. Age65 is 1 if leaders are older than 65, 0 otherwise. Education is 1 if leader's education is college or higher, 0 otherwise. Central is 1 is the leader has worked in central department, 0 otherwise. SOE is 1 if one leader has worked as the leader of SOE, 0 otherwise. Years of party are the number of years since the leader joined the Party. Origin of Shanghai is 1 if the leader has worked in Shanghai, 0 otherwise. Communist Youth League is 1 if the leader has worked as member in communist Youth League, 0 otherwise. Home is 1 if the leader worked in the province where she was born, o otherwise. Tenure is the number of years a leader has been in the position.

Table 2 Number of rotations in each province after 1993



to other provinces.[44] [45]

In summary, rotation is one important form of management over provincial leaders, and we will look at how the rotation is implemented in next section.

6 How is provincial chief leader being rotated?

In this part, we look at result of assignment over provincial leaders. We use three measures (Mendes et al, 2007) to test the matching between leaders and the economic development before rotation is done: Correlation coefficients, Spearman rank correlation coefficients and the regression coefficients between the two sides of matching. The economic development is represented by real GDP per capita, Y^i_{t-1}. Leader's ability is shown by $TFP^j_{average}$ in the previous province before rotation.

There is only one observation or no observations in some years, so we do not rely on the results for each individual year, because of the data limitation. The analysis will be based on overlapping data. Rotation is taken place each year with different times, and one exception is 1996. There is

[44] For example, since 1978, there are 8 leaders who have worked in Xinjiang. 1 is promoted, 5 are retired, and 2 are still working there. In Inner Mongolia, 9 leaders are retired, and 2 are still working there. Among 14 leaders who have worked in Heilongjiang, 1 is promoted, 8 are retired, and 5 are still working there. Among the 14 leaders who have worked in Shanghai since 1978, 50% were promoted to higher position in the central government, 36% were get retired, and 14% are still working in Shanghai as chief leaders. There are 14 leaders who have worked in Guangdong since 1978. Among them 57% leaders are promoted, 21.5% are retired, and 21.5% are still staying in Guangdong as chief leaders.

[45] For some special provinces, e.g. Xinjiang, Inner Mongolia, Yunnan and Heilongjiang, the stability of provincial leaders is important for the social stability of these provinces in the national frontier. Leaders in these provinces are more likely to get promotion, for example, in the form of cross-posting, or get retired after the term. Leaders in Shanghai are more than seven times to be promoted than leaders in other provinces (See Bo, 1996). Many leaders are promoted to higher positions or get retired rather than being rotated to other provinces. This is similar for the municipality of Tianjin, although its promotion possibility is lower than Shanghai. Guangdong is in the frontier of economic reform. More advanced economic policies and economic experiments are implemented in Guangdong since the beginning of economic reform. Economic experiment might be an opportunity for one's career if other provinces could follow. Knowing this, more ambitious leaders could initiate more economic reforms (Xu, 2010). From our data, we find that leaders in Guangdong are usually getting promotion instead of being rotated.

Table 3 The correlation coefficients between ability of each leader (average TFP over tenure) and GDP per capita one year before rotation with five-year overlapping data

year	correlation	Spearman rank correlation	regression of ability on provincial economic development	n
1993-1998	0.390	0.300	0.780	11
1994-1999	0.618	0.357	0.916*	8
1995-2000	0.594	0.429	0.890	7
1997-2001	0.736*	0.685*	1.504*	10
1998-2002	0.253	0.333	0.395	12
1999-2003	0.123	0.205	0.158	11
2000-2004	0.182	0.182	0.234	10
2001-2005	0.183	0.228	0.239	12
2002-2006	-0.269	-0.228	-0.282	8
2003-2007	-0.053	-0.002	-0.028	15
2004-2008	-0.091	-0.066	-0.050	15

* Significant at 10%, ** significant at 5%, *** significant at 1%.

There is no rotation in 1996, so there is no correlation for the period 1996-2000. There is no ability in 2000 because the statistics for Tibet is missing, so the result for 2000-2004 is the same as 2001-2004. Similarly, the result for 2002-2006 is the same 2002-2005 because the missing information in 2006.

no rotation for chief leaders in 1996, but several turnovers for vice leaders[46].

We use five years overlapping data to look at the correlation between ability and provincial economic development. The result is reported in table 3. From 1993 to 2008, the correlation coefficients are different in different periods. Central authority adjusts the ways in allocating provincial leaders as it changes in objective function.

In the beginning period from 1993 to early 2000s, most of correlation coefficients and Spearman rank correlation coefficients are positive every five years. Therefore positive assortative matching is implemented. More capable leaders are allocated to more developed provinces. From 1997 to 2001, all the correlations coefficients and regression coefficient are positive and significant. And they are stronger than other coefficients.[47] More capable leaders are assigned to more developed provinces. This reflects that central authority's γ is close to 1. As leaders and provincial economic development are complementary, this assignment could generate the largest output in the whole nation.

[46] In 1996, there are rotation of provincial vice leaders, and rotations between central department and provinces. For example, one vice governor is rotated from Jilin to Guizhou, and one leader is rotated from vice minister of Ministry of Chemical Industry to Fujian as governor. We only focus on provincial chief leaders, so the rotation of vice leaders is not included.

[47] Correlation of traits between the two sides show the degree of similarity on the traits of the two sides. Our positive correlation coefficient shows the degree of positive assortative matching across the trait (although not perfect assortative matching).

After early 2000s, negative assortative matching between leaders and provinces is implemented.[48] Capable leaders who have better TFP performance are allocated to less developed provinces. The correlation coefficients are negative after early 2000s. Large regional disparities, which will reduce the social stability and long run economic growth, is a driving force for central authority to concern more in achieving balanced development. The change of assignment is consistent with the central policies in emphasizing the development of inland regions since early 2000s. In addition, in 2003 the general secretary of the Communist Party, the premier, and the members of standing committee of the political bureau are replaced by a new generation of leaders. The change of members in central authority is accompanied by policies changes in managing provincial leaders and the effects on economic development (Jones and Olken, 2005, 2009). This result with five years overlapping data is consistent with our argument in proposition 1 that central objective determines the mode of assignment.

To get more robust result, we use the same methods to obtain the results with two years overlapping data, and results are shown in table 4. Although the number of observations is small in each time period, the trend of allocation does not change. It is positive for correlation coefficients and rank correlation coefficients before early 2000s. The correlation coefficients are negative after early 2000s, and this reflects that more capable leaders are allocated to less developed provinces. Although the correlation coefficients are not significant because of the small sample, we could infer the change of the trend of allocating leaders to provinces.

Besides, we calculate the correlation coefficients based on different time periods to see whether central authority gives different emphases on economic growth and balanced development with four years overlapping data and three years overlapping data. The results are shown in table A4 and table A5. These correlation coefficients reflect that before early 2000s, the assignment is positive assortative matching, while after early 2000s, negative assortative matching is implemented. And this is consistent with the results in table 3 and table 4.

In general, from early 1990s to early 2000s, central authority assigns provincial leaders with higher abilities to more developed provinces to generate the largest national output. After early 2000s, more capable leaders are allocated to less developed regions and this is used as one way to reduce regional disparity. To further identify the difference of assignment before and after early 2000s, we regress the leader's ability $TFP^j_{average}$ on the GDP per capita one year before rotation Y^i_{t-1} by adding the dummy of time period, which is 1 if year is 1998 or afterwards, and 0 otherwise[49]. In table 5, we find that the coefficient for the dummy is -0.034, which is significant. This confirms that after early 2000s, the allocation between leaders and provinces is significantly different from the period from 1993 to early 2000s. The coefficient for Y^i_{t-1} is positive and insignificant. This reflects in the whole time period, the assignment of leaders to provinces is mixed with both positive and negative assortative matching. In column (2), the interaction item between time dummy and Y^i_{t-1} is significant, and this further proves the change of direction in assignment from positive

[48] The central authority has realized the importance of reducing the regional disparity since late 1990s. However, the implementation will be several years later because of the lag effects.

[49] The change of central objective might not happen one detailed time, but in a time period around early 2000s. Similar results are obtained if the dummy is set in other years in early 2000s. According to Xu (2010), it happens after 2 decades of economic reform. Therefore we use 1998 to divide the time period.

Table 4 The correlation coefficients between ability of each leader (average TFP over tenure) and GDP per capita one year before rotation with two years overlapping data

year	correlation	Spearman rank correlation	Regression of ability on provincial economic development	n
1993-1994	0.689	0.371	3.308	6
1994-1997	0.883	0.800	0.977	4
1997-1998	0.517	0.400	1.036	4
1998-1999	0.511	0.000	0.804	4
2000-2001	0.762	0.800	1.615	4
2001-2002	0.287	0.347	0.432	8
2002-2003	-0.335	-0.359	-0.371	5
2003-2005	-0.356	-0.400	-0.111	4
2005-2007	-0.098	-0.014	-0.054	13
2006-2007	-0.148	-0.141	-0.086	11
2007-2008	-0.163	-0.161	-0.094	12

* significant at 10%, ** significant at 5%, *** significant at 1%.

There is no rotation in 1996, so there is no correlation for the period 1993-1996. There are only two observations from 1994 to 1995, so we do not report results for this period. There are only three observations from 2003 to 2004, so we do not report the result in this period. The ability for leaders in 2000 is missing, so we do not report the result for 1998-2000, and it is the same as 1998-1999. We do not report the results if there are only three observations in some periods, for example, 1995-1997, 1999-2000, and 2005-2006.

For periods with only three observations, we report the results for one more year afterwards or backwards.

Table 5 The regression of ability on the independent variable of time dummy

Dependent variable: ability measured by TFP over the tenure		
Independent variables	(1)	(2)
real GDP per capita before rotation	0.001	0.012*
	(0.001)	(0.007)
dummy	-0.034**	-0.003
	(0.015)	(0.026)
Interaction of dummy and real GDP per capita before rotation		-0.012*
		(0.007)
R square	0.13	0.20
N	37	37

** significant at 5%, * significant at 10%

Dummy=1 if year of rotation is 1998 or afterwards, and 0 otherwise

assortative matching to negative assortative matching.

The assignment of provincial leaders to each province reflects the change of central concentration on total economic output and regional development balance. If leaders with higher abilities are assigned to more developed provinces, this reflects that central authority intends to achieve the largest output in the whole nation. On the other hand, if provincial leaders with higher abilities are allocated to less developed provinces, then central authority concentrates more on reducing regional disparity. The assignment of leaders is closely related to the process of economic reform and development. Before early 2000s, regulation over provincial leaders is serving for the economic development in the way that more capable leaders are rotated to more developed regions. After early 2000s, when regional disparity turns to be larger and affecting the long-run economic growth, central authority concerns more in reducing regional disparity among regions by implementing negative assortative matching.

The correlation coefficients might not be quite significant because of the small sample; however, we could obtain the trend and the change of the central allocation of leaders from more positive assortative matching to more negative assortative matching.

7 Alternative explanation

Previously we explore the assignment of leaders based on one dynamic model. In this part, we consider an alternative, which is one static model. One simplified production function of each province is determined by the endowment E^i and leader' ability A,

$$Y^i = f(E^i, A)$$

Where Y^i is the economic development level in province i. This production function satisfies,

$$\frac{\partial Y^i}{\partial E^i} > 0, \frac{\partial Y^i}{\partial A} > 0$$

And we assume that it is complementary between endowment and leader's ability in generating outputs[50].

$$\frac{\partial Y^i}{\partial E^i \partial A} > 0$$

Given the complementarity in production function, we know positive assortative matching could generate the largest output, and negative assortative matching could generate the smallest regional disparity. Therefore, proposition 1 could be applied when the assignment is changing to the case between E^i and A. We look at the assignment between E^i and A. Ability is measured by average TFP growth rate $TFP_{average}$.To empirically obtain E, we take similar method of fixed effect model as Mendes et al (2007) to measure the time-constant provincial characteristics using the matched leader-province data.

Fixed effect model has been widely used in the literature. Mendes et al (2007) obtain firm-specific productivity for each firm and look at its relationship with workforce skills in each firm to access the assortative matching in labor market. Similarly, Mion and Naticchioni (2009) obtain worker's fixed effect to measure worker's unobserved ability[51]. Postel-Vinay and Robin (2006) measure worker's skill by worker's individual fixed effect[52]. In Abowd et al (2004), firm quality is presented by the firm fixed effect, and worker's skill is represented by worker's individual fixed effect[53]. Similarly, Andrews, Schank and Upward (2006) proposed several ways for fixed effect estimation. In order to estimate fixed effects in two dimensions (workers and firms), the dependent variable needs to vary at the worker level. We do not apply the method of Abowd et al (2004) and Andrews et al (2006) in this paper because we do not have the dependent variable at the leader's level. In our case, we obtain provincial fixed effect, which measures the province-specific productivity of each province.

Following Barro (1990), Zhang and Zou (1998), we analyze the following equation to obtain provincial fixed effect,

$$g_{it} = \alpha + \beta X_{1_{it}} + \theta X_{2_{it}} + u_i + \delta_t + \epsilon_{it}$$

Where subscript i is province, t is time. g_{it} is the growth rate of GDP per capita in each

[50] The production function is determined by A and E. If investment is also considered as a factor for production, and it is substitute to endowment. The return rate will be decreasing if more investments are implemented in better endowed regions, therefore some investments will go to worse endowed regions. And this could not be reflected in our framework.

[51] Mion and Naticchioni (2009) consider the correlation between individual fixed effect (obtained from employees' wages) and firm size and they show that it is positive assortative matching between firm size and skills of workers presented by individual fixed effects. Similarly, in order to obtain leader's fixed effect we need to use the one dependent variable related to leaders' performance or leader's achievement. In our case, we do not have such variable except the turnover of leaders. However, the leader's turnovers are determined by many related variables besides their abilities. Leader's fixed effects could not be obtained because it cannot be identified separately from that of the province when we use the provincial variable as dependent variable. Therefore we do not use this fixed effect method in this paper.

[52] They measure the firm quality using the log of value added per worker, and they find that it is positive correlation between firm quality and worker's skill.

[53] They find that it is slightly positive between firm quality and worker's skills in US, and it is negative in France.

province i at time t. $X_{1_{it}}$ includes the provincial economic characteristics related to economic growth, which are the growth rate of investment in fixed asset, education, the working population, and the degree of openness[54]. $X_{2_{it}}$ includes the leader's characteristics, which are education, age, central working experiences and gender. δ_t is the time effect. u_i is the fixed effect.

After obtaining the provincial fixed effects, we replace Y^i_{t-1} with this time-constant provincial fixed effect, and similar methods in section 6 are applied to look at the assignment between leaders and provinces. Leaders who have been rotated between provinces (eg. from province j to province i, $j \neq i$) are used as the sample. $TFP^j_{average}$ might be affected by the endowment in previous province, E^j, but E^j is not related to the current provincial endowment E^i. Therefore the correlation between $TFP^j_{average}$ and E^i could reflect the mode the assignment between leaders and provinces

Results with five-year overlapping data are shown in table 6. It is obvious to see that the mode of the assignment is similar with section 6. The correlation coefficients are positive and significant from 1993 to 1998 and from 1997 to 2001. The change of the trend in assignment begins in early 2000s. After early 2000s, the correlation coefficients turn to be negative. This suggests that the assignment is changing from positive assortative matching to negative assortative matching.

In table 7, we list the correlation results for two years overlapping data, and results are similar as table 4. The coefficients are positive before early 2000s, and leaders with higher abilities are assigned to provinces with higher provincial specific productivities. The correlation coefficients are positive and significant from 1993 to 1994. After early 2000s, most of the correlation coefficients are negative. Hence, more negative assortative matching is implemented. Results with four years overlapping data and three years overlapping data are listed in table A6 and table A7, and the results are consistent with table A4 an table A5 respectively.

There are some differences between correlation and rank correlation coefficients. The main difference between correlation and Spearman rank correlation is that rank correlation could mitigate the effect of extreme values on the correlation coefficients. For example, from 2001 to 2005 in table 6, Spearman rank correlation and correlation coefficients are not consistent, however, both of two coefficients are quite small, and this suggests that the correlation between ability of leaders and provincial fixed effect is not strong. So we believe that there is no obvious trend of the correlation in this time period. Similar explanations could be used for other inconsistencies between correlation and Spearman rank correlation coefficients.

Furthermore, identification of the correlation between leaders and provinces in section 6 and this section shares the same method; however, there are some differences in correlation coefficients in table 3 and table 6. In this section, assignment is based on $TFP^j_{average}$ and E^i. In section 6, correlation is between Y^i_{t-1} and $TFP^j_{average}$. Y^i_{t-1} is affected by previous leaders' effects before time $t-1$ besides provincial endowment. This will make the absolute values of correlation coefficients between Y^i_{t-1} and $TFP^j_{average}$ in table 3 larger than the correlation coefficient between $TFP^j_{average}$

[54] Investment is the accumulation rate of fixed investment in fixed asset; the degree of openness is the ratio of the sum of export and import divided by provincial GDP; working population is the growth rate of working population between 15 and 64 in each province. Education is growth rate of educated people with higher education in each province.

Table 6 The correlation coefficients between ability of each leader (average TFP over tenure) and provincial fixed effect with five-year overlapping data

year	correlation	spearman rank correlation	regression of ability on provincial fixed effect	n
1993-1998	0.553*	0.391	0.539*	11
1994-1999	0.568	0.429	0.403	8
1995-2000	0.553	0.429	0.387	7
1997-2001	0.705*	0.636*	0.647*	10
1998-2002	0.316	0.197	0.255	12
1999-2003	0.030	0.005	0.019	11
2000-2004	0.056	0.049	0.036	10
2001-2005	-0.017	0.046	-0.010	12
2002-2006	-0.340	-0.132	-0.160	8
2003-2007	-0.076	0.030	-0.060	15
2004-2008	-0.134	-0.073	-0.111	15

* Significant at 10%, ** significant at 5%, *** significant at 1%.

There is no rotation in 1996, so there is no correlation for the period 1996-2000. There is no ability in 2000 because the statistics for Tibet is missing, so the result for 2000-2004 is the same as 2001-2004. Similarly, the result for 2002-2006 is the same 2002-2005.

and E^i in table 6. At the same time, the correlation coefficient between Y^i_{t-1} and $TFP^j_{average}$ considers partial effect of E, because the effect of E from the growth rate of g is not included[55]. And the correlation coefficient between E and $TFP^j_{average}$ in this section includes all the effect of E. This might induce the absolute values of correlations in table 3 less than the absolute values in table 6. As a result, these two concerns would induce that some coefficients in table 3 are larger than table 6, and some are smaller. On the other hand, the small sample might also contribute to the differences between table 3 and table 6. Similar analysis could be applied to between table 4 and table 7, between table 5 and table 8.

Finally, to compare with table 5, we regress the $TFP^j_{average}$ on the provincial fixed effect, E^i, and the result is shown in table 8. We obtain similar result that the time dummy is significant and negative. The coefficient is -0.029 and this is similar with the coefficient of dummy in table 5, -0.034. This confirms the differences in assignment before and after early 2000s. In column (2), the interaction item between time dummy and E^i is negative and significant. This further confirms the change of assignment over provincial leaders from positive assortative matching to negative assortative matching.

[55] $Y^i_t = Y^i_{t-1}[1 + g^i_t(A, E_i)]$,and $Y^i = f(A, E^i)$ are two forms of expression for the output at province i. In the former dynamic expression, the correlation between A and Y^i_{t-1} ignores the possible effect of endowment through growth rate $g^i_t(A, E_i)$. Therefore only partial endowment in counted. This is clearer when explaining it in the regression form, $A = \alpha_0 + \alpha_1 Y^i_{t-1} + e$. Some effects of endowment (in the growth rate g) is entering in the error term, so α_1 does not reflect all the effects of endowment. But this problem does not exist in the function, $Y^i = f(A, E^i)$.

Table 7 The correlation coefficients between ability of each leader (average TFP over tenure) and GDP per provincial fixed effect with two-year overlapping data

year	correlation	Spearman rank correlation	Regression of ability on provincial fixed effect	n
1993-1994	0.819*	0.371	1.220**	6
1994-1997	0.770	0.800	0.418	4
1997-1998	0.577	0.400	0.828	4
1998-1999	0.513	0.000	0.363	4
2000-2001	0.409	0.400	0.354	4
2001-2002	0.217	0.060	0.174	8
2002-2003	-0.309	-0.359	-0.156	5
2003-2005	-0.351	-0.400	-0.055	4
2005-2007	-0.105	0.008	-0.087	13
2006-2007	-0.161	-0.105	-0.142	11
2007-2008	-0.179	-0.147	-0.154	12

* significant at 10%, ** significant at 5%, *** significant at 1%.

There is no rotation in 1996, so there is no correlation for the period 1993-1996. There are only two observations from 1994 to 1995, so we do not report results for this period. There are only three observations from 2003 to 2004, so we do not report the result in this period. The ability for leaders in 2000 is missing, so we do not report the result for 1998-2000, and it is the same as 1998-1999. We do not report the results if there are only three observations in some periods, for example, 1995-1997, 1999-2000, and 2005-2006.

For periods with only three observations, we report the results for one more year afterwards or backwards.

Table 8 The regression of ability on the independent variable of time dummy

Dependent variable: ability measured by TFP over the tenure		
Independent variables	(1)	(2)
Provincial fixed effect	0.142	0.007**
	(0.146)	(0.003)
dummy	-0.029**	-0.018
	(0.014)	(0.015)
Interaction of dummy and provincial fixed effect		-0.007**
		(0.003)
R square	0.13	0.24
N	37	37

** significant at 5%, * significant at 10%

Dummy=1 if year of rotation is 1998 or afterwards, and 0 otherwise

8 Robust check

In this part we try to look at the degree of assortative matching (Liu and Lu, 2006) between leaders and provinces based on equation (10) to infer the change of γ. The dichotomous traits between $TFP^j_{average}$ and Y^i_{t-1} are divided into two groups based on the median values. If the trait is larger than the median value, then it is 1, and 0 otherwise. Moreover, as the regional disparity mainly exists between inland regions and eastern regions[56], we give another exogenous and dichotomous division for provincial characteristics. Provinces are divided into (0,1) based on their locations. It is 1 if one province is in east regions and 0 otherwise.

The degree of matching for five-years overlapping data is shown in table 9. The degrees using standards to divide the traits into 0 and 1 are similar. Degree (1) is using the median value as the standard and degree (2) is using provincial location as the standard, keeping the division of ability same as degree (1). In the period from 1993 to 1998, it is 0.67 for degree (1) and 1 for degree (2). This reflects the distances of actual matching to random matching when it is positive assortative matching. The differences of the degrees come from the standard of dividing the traits into (0,1). Before early 2000s, all measures for the degree of assortative matching are positive. The coefficients measure the degree of positive matching and this reflects that central authority gives more concerns to economic growth in its objective function.

Since late 1990, the degree of matching is turning to be negative. After 2003, both degrees are negative, and this shows the distance of actual matching to perfect random matching when it is negative assortative matching. The negative degree reflects that leaders with higher abilities are allocated to less developed regions because central authority pays more attention to reduce regional disparity.

Compared to table 3, negative assortative matching happens earlier, especially with result of degree (2). Since 2002 it is negative assortative matching in table 3, while in degree (1), it is random matching from 2002 to 2005. And the mode of matching is consistent afterwards. To compare table 9 with table 6, we find that the general trend of assignment over provincial leaders is consistent, and the negative assortative matching happens earlier in table 9. This might be induced by the different methods of calculation for the degree. The method in calculating the degree of assortative matching in Liu and Lu (2006) uses one exogenous standard of dividing the traits of matching. In column (1), we use the median value of each period as the standard to divide the traits, and this absence of objective standard for each time period in dividing the trait might induce the inconsistency. In column (2), the trait of provinces is exogenous, and the other trait of ability is divided based on whether larger or smaller than median value of each group. However, the trend and change in matching keep the same.

In table 10, the degree of matching with two years overlapping data is reported. Column (1) and (2) use the same methods as column (1) and (2) in table 6. The results of assortative matching show similar trend as previous results. For the result in each column, it is obvious to see that before early 2000s, more positive assortative matching is implemented, and after 2000s

[56] Eastern regions include 11 provinces, which are Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan. All remain provinces belong to inland regions.

Table 9 The degree of assortative matching between ability of each leader (average TFP over tenure) and provincial characteristics with five-year overlapping data

year	Degree (1)	Degree (2)	n
1993-1998	0.667	1.000	11
1994-1999	0.500	0.500	8
1995-2000	0.500	1.000	7
1997-2001	0.667	0.667	10
1998-2002	0.667	0.667	12
1999-2003	-0.333	-0.333	11
2000-2004	0.500	0.000	10
2001-2005	0.333	-0.333	12
2002-2005	0.000	-0.667	8
2003-2007	-0.250	-0.250	15
2004-2008	-0.250	-0.250	15

* Significant at 10%, ** significant at 5%, *** significant at 1%. There is no rotation in 1996, so there is no degree for the period 1996-2000. The degree of matching is obtained by applying the equation of the measure of equation (7). The dichotomous trait is divided by whether the measure of ability or GDP per capita is larger or smaller than the median value. It is 1 if the trait is larger than the median value, and it is 0 otherwise for the column of degree (1). The dichotomous trait in degree (2) is divided by exogenous standard. If one province is belong to east regions, then the related GDP level is 1, 0 otherwise. If one leader's ability is above the median value in the whole sample, it is 1, 0 otherwise.

Table 10 The correlation coefficients between ability of each leader (average TFP over tenure) and provincial characteristics with two years overlapping data

year	Degree (1)	Degree (2)	N
1993-1994	-0.500	0.500	6
1994-1997	1.000	1.000	4
1997-1998	0.000	1.000	4
1998-1999	0.000	0.000	4
2000-2001	1.000	1.000	4
2001-2002	0.500	0.500	8
2002-2003	-0.333	-0.333	5
2003-2005	0.000	-1.000	4
2005-2007	0.250	0.250	13
2006-2007	-0.250	-0.333	11
2007-2008	0.000	0.000	12

* Significant at 10%, ** significant at 5%, *** significant at 1%.

There is no rotation in 1996, so there is no degree for the period 1993-1996. There are only two observations from 1994 to 1995, so we do not report results for this period. For other periods with only three observations, we report the results for one more year afterwards or backwards.

The degree of matching is obtained by applying the equation of the measure of equation (10). The dichotomous trait is divided by whether the number is larger or smaller than the median value for the column of degree (1). It is 1 if larger than median value, and 0 otherwise. The dichotomous trait in degree (2) is divided by exogenous standard. If one province is belong to east regions, then the related GDP level is 1, 0 otherwise. If one leader's ability is above the median value in the whole sample, it is 1, 0 otherwise.

more negative assortative matching is implemented. There are some differences in the degree of matching because the standard of dividing the two sides of matching into (0,1) are different, and this could generate different number of observation for each type of trait. Compared to table 6, more random matching with degrees equal to 0 appears.

Compared to results in table 4 and table 7, we achieve similar trend of matching in table 10. In most cases, the results for the degree of assortative matching and correlation coefficients are consistent (Liu and Lu, 2006). Since 2002, more negative assortative matching is implemented. This further confirms our findings in the previous section about the change in assignment before and after early 2000s. However, because the standards of dividing abilities and provincial GDP per capita level are not unique and exogenous, there are some exceptions in the degree assortative matching.[57]

[57] There might be some inconsistencies between the degree of matching and the correlation coefficients. This is because the degree is calculated based on the dichotomous traits, and the standards of dividing the ability and GDP are not objective. In addition, the sample of this paper is not large, different divisions of the trait will generate

9 Summary

In this paper, we discuss the central management over provincial leaders through assignment of leaders to provinces. How to match provincial leaders and provinces is a sophisticated project and it is determined by the central authority's objectives. The assignment could involve considerations of political stability, ethic relationship, economic growth, etc, and we deal with the problem from the side of economic development. With the sample of Chinese provincial chief leaders who are rotated among provinces, we find that the assignment of provincial chief leaders to provinces is closely related to the managing policy of central authority and economic reform process.

The results suggest that from early 1990s to early 2000s, more positive assortative matching is implemented in the way that central authority allocates more capable leaders to more developed regions, and after early 2000s, more negative assortative matching is implemented in the way that provincial leaders with high abilities are allocated to less developed provinces. Through central rotation, both central authority and provincial leaders are playing great roles in developing regional economy in China. Both traditional correlation coefficients and degree of measure of assortative matching are applied to look at the direction of assignment and the extent of assortative matching.

At the same time, we have to admit that although the empirical evidence is supportive to the theoretical model of assortative mating, the results are not quite strong because of the small sample of observations for rotated leaders. Further works could be done to get more strong and significant results, for example, to explore the ways of measuring the abilities of leaders who are not involving with any rotations.

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different results. For example, whether the median value for ability and GDP should be 0 or 1, and different setup for this could generate different degrees. So there might be some inconsistencies, but this does not violate the argument.

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Figure A1 Ratio of average real GDP per capita between non-eastern regions and eastern regions

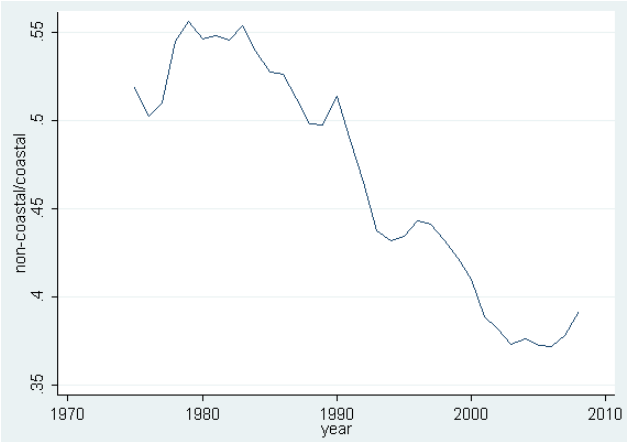

Figure A2 Coefficient of variation for real GDP per capita

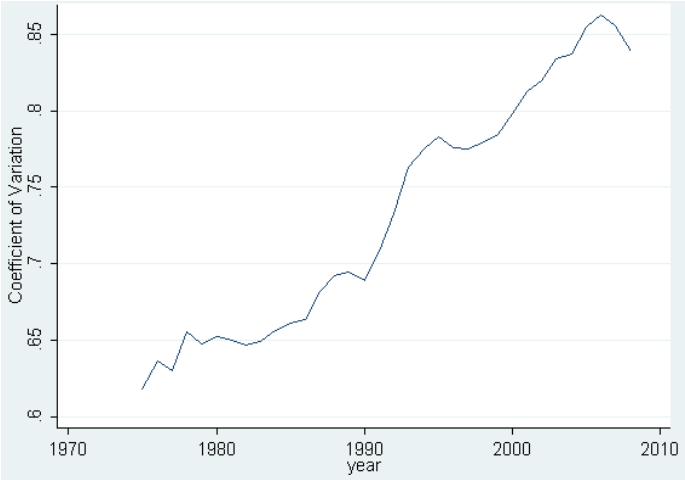

Table A1 The average amount and increasing rate of fix asset investment in east and central-west provinces

year	increasing rate in east regions	increasing rate in central-west regions	Average investment in east regions	Average investment in central-west regions
1979	17.18%	8.41%	28.82	16.47
1980	23.02%	21.56%	35.57	20.22
1981	26.34%	1.82%	44.63	21.37
1982	25.06%	34.27%	55.62	27.96
1983	12.59%	18.36%	62.28	33.04
1984	30.31%	36.18%	79.28	43.24
1985	47.57%	44.48%	115.94	61.17
1986	17.53%	10.27%	138.47	66.65
1987	20.99%	15.04%	171.89	77.27
1988	24.78%	18.09%	216.02	91.50
1989	-3.04%	-5.73%	197.06	84.42
1990	9.67%	10.79%	213.22	92.52
1991	26.11%	24.32%	266.06	114.07
1992	52.24%	35.19%	406.96	155.08
1993	68.13%	50.38%	677.86	233.79
1994	36.96%	25.43%	911.91	300.27
1995	21.30%	22.93%	1111.48	365.56
1996	11.39%	15.98%	1250.66	431.23
1997	8.50%	13.73%	1355.95	485.74
1998	10.11%	14.83%	1488.16	553.51
1999	6.00%	8.55%	1575.48	581.92
2000	7.53%	14.92%	1704.77	657.21
2001	11.13%	18.37%	1897.65	760.89
2002	14.10%	19.34%	2198.50	892.58
2003	29.42%	26.57%	2921.83	1123.21
2004	24.72%	26.68%	3673.77	1444.17
2005	22.22%	26.52%	4529.70	1863.45
2006	21.33%	26.43%	5484.25	2386.19
2007	22.01%	28.34%	6573.75	3124.10
2008	22.88%	28.99%	7977.69	4066.95
2009	27.45%	39.18%	9978.70	5786.69

Data resources: China Statistical Yearbooks The unit of amount is 100 million. East regions include Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan. Other provinces belong to central and west regions.

Table A2 The increasing rate and average amount of transfers from central government to local government in east and central-west regions

year	Growth rate in east region	Growth rate in central-west regions	Average amount in east regions	Average amount in central-west regions	Total amount in east regions	Total amount in central-west regions
1994			73.5234	60.63213	1180	1210
1995	7.78%	15.57%	79.1013	63.36358	1270	1270
1996	2.38%	21.09%	80.512	69.20784	1290	1380
1997	4.68%	8.73%	83.5074	73.23904	1340	1460
1998	8.97%	25.27%	91.5245	91.04689	1460	1820
1999	11.24%	30.20%	103.0955	117.1374	1650	2340
2000	13.68%	26.21%	113.944	146.2272	1820	2920
2001	13.72%	41.13%	129.1905	202.5069	2070	4050
2002	33.04%	18.02%	162.3418	237.762	2600	4760
2003	14.97%	5.62%	187.0148	253.2976	2990	5070
2004	25.12%	28.30%	228.3756	326.1502	3650	6520
2005	2.26%	19.08%	247.092	382.4431	3950	7650
2006	14.02%	21.32%	288.0007	465.7916	4610	9320
2007	13.20%	32.87%	303.9037	617.1592	4560	12300

The unit of amount is 100 million

East regions include Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan. Other provinces belong to central and west regions.

Data resource: Finance Yearbook of China

Table A3 The general statistics of TFP growth rate from 1985 to 2008

province	mean	median	standard deviation	variance	min	max
11	7.07%	5.64%	6.69%	0.45%	0.47%	33.65%
12	1.24%	1.16%	3.30%	0.11%	-6.98%	7.55%
13	4.80%	4.56%	4.09%	0.17%	-1.73%	15.75%
14	4.47%	5.86%	5.64%	0.32%	-5.82%	17.82%
15	5.23%	4.45%	4.16%	0.17%	-3.31%	14.66%
21	3.56%	4.17%	4.38%	0.19%	-3.85%	11.66%
22	4.35%	4.91%	4.96%	0.25%	-4.14%	20.41%
23	3.00%	3.19%	2.72%	0.07%	-3.65%	7.14%
31	4.06%	3.65%	4.15%	0.17%	-3.82%	14.26%
32	5.96%	5.25%	4.86%	0.24%	-2.26%	16.46%
33	7.32%	7.04%	5.32%	0.28%	-1.96%	18.42%
34	3.91%	4.61%	5.65%	0.32%	-9.22%	13.54%
35	6.01%	4.09%	6.46%	0.42%	-5.43%	17.27%
36	5.27%	5.44%	3.67%	0.13%	-4.84%	12.59%
37	6.18%	6.07%	3.84%	0.15%	-0.78%	17.26%
41	5.32%	5.01%	3.75%	0.14%	-1.03%	12.75%
42	3.42%	3.93%	6.18%	0.38%	-19.32%	15.60%
43	4.05%	4.70%	3.83%	0.15%	-4.82%	10.44%
44	8.18%	7.10%	4.18%	0.18%	1.34%	17.20%
45	5.73%	6.44%	3.68%	0.14%	-1.35%	11.18%
46	3.58%	2.84%	3.77%	0.14%	-0.59%	9.38%
51	5.25%	4.95%	2.87%	0.08%	0.85%	11.93%
52	4.41%	2.84%	3.75%	0.14%	0.24%	14.26%
53	3.41%	2.53%	3.98%	0.16%	-2.08%	11.69%
61	5.44%	4.93%	3.03%	0.09%	-0.45%	11.33%
62	4.20%	4.75%	4.18%	0.17%	-6.18%	17.29%
63	2.94%	2.65%	3.63%	0.13%	-3.90%	10.69%
64	3.89%	2.83%	4.11%	0.17%	-3.16%	14.61%
65	5.14%	4.77%	3.86%	0.15%	-0.69%	13.42%
National average	4.79%	4.48%	4.57%	0.21%	-19.32%	33.65%

Table A4 The correlation coefficients between ability of each leader (average TFP over tenure) and GDP per capita one year before rotation with four years overlapping data

Year	correlation	Spearman rank correlation	regression of ability on provincial economic development	n
1993-1997	0.581	0.600*	1.223*	9
1994-1998	0.529	0.371	0.708	6
1995-1999	0.594	0.429	0.890	7
1997-2000	0.732*	0.543	1.271	6
1998-2001	0.631*	0.595	1.229	8
1999-2002	0.197	0.280	0.262	10
2000-2003	0.168	0.259	0.235	9
2001-2004	0.182	0.182	0.234	10
2002-2005	-0.269	-0.228	-0.282	8
2003-2006	-0.356	-0.400	-0.111	4
2004-2007	-0.077	-0.055	-0.042	14
2005-2008	-0.111	-0.015	-0.061	14

* significant at 10%, ** significant at 5%, *** significant at 1%.

There is no rotation in 1996, so there is no correlation for the period 1993-1996. There is no observation in 2000, so the result of 1997-2000 is similar as 1997-1999. There is observation in 2006, so the result of 2003-2006 is the same as 2003-2005.

Table A5 The correlation coefficients between ability of each leader (average TFP over tenure) and GDP per capita one year before rotation with three years overlapping data

Year	correlation	Spearman rank correlation	regression of ability on provincial economic development	n
1993-1995	0.660	0.286	2.985*	7
1994-1997	0.883	0.800	0.977	4
1995-1998	0.433	0.400	0.570	5
1997-1999	0.732*	0.543	1.271*	6
1998-2000	0.511	0.000	0.804	4
1999-2001	0.609	0.600	1.166	6
2000-2002	0.287	0.347	0.432	8
2001-2003	0.168	0.259	0.235	9
2002-2004	-0.273	-0.348	-0.280	6
2003-2005	-0.356	-0.400	-0.111	4
2005-2007	-0.098	-0.014	-0.054	13
2006-2008	-0.163	-0.161	-0.094	12

* significant at 10%, ** significant at 5%, *** significant at 1%.

There is no rotation in 1996, 2000, and 2006. If there are only three observations in some periods, we do not report the results.

Table A6 The correlation coefficients between ability of each leader (average TFP over tenure) and provincial fixed effects with four years overlapping data

Year	correlation	Spearman rank correlation	regression of ability on provincial economic development	n
1993-1997	0.714*	0.550	0.695	9
1994-1998	0.440	0.371	0.287	6
1995-1999	0.553	0.429	0.387	7
1997-2000	0.765*	0.543	0.686	6
1998-2001	0.494	0.429	0.398	8
1999-2002	0.170	0.085	0.130	10
2000-2003	0.044	-0.008	0.029	9
2001-2004	0.056	0.049	0.036	10
2002-2005	-0.340	-0.132	-0.160	8
2003-2006	-0.351	-0.400	-0.055	4
2004-2007	-0.113	-0.020	-0.095	14
2005-2008	-0.124	-0.037	-0.102	14

* significant at 10%, ** significant at 5%, *** significant at 1%.

There is no rotation in 1996, so there is no correlation for the period 1993-1996. There is no observation in 2000, so the result of 1997-2000 is similar as 1997-1999. There is observation in 2006, so the result of 2003-2006 is the same as 2003-2005.

Table A7 The correlation coefficients between ability of each leader (average TFP over tenure) and provincial fixed effects with three years overlapping data

Year	correlation	Spearman rank correlation	regression of ability on provincial economic development	n
1993-1995	0.700*	0.179	0.865	7
1994-1997	0.770	0.800	0.418	4
1995-1998	0.363	0.400	0.224	5
1997-1999	0.765*	0.543	0.686	6
1998-2000	0.513	0.000	0.363	4
1999-2001	0.365	0.371	0.315	6
2000-2002	0.217	0.060	0.174	8
2001-2003	0.044	-0.008	0.029	9
2002-2004	-0.286	-0.232	-0.142	6
2003-2005	-0.351	-0.400	-0.055	4
2005-2007	-0.105	0.008	-0.087	13
2006-2008	-0.179	-0.147	-0.154	12

* significant at 10%, ** significant at 5%, *** significant at 1%.

There is no rotation in 1996, 2000, and 2006. If there are only three observations in some periods, we do not report the results.