Centralized Deployment and Teachers' Incentive: Evidence from Reforms in Rural China*

Li Han†, Mingxing Liu‡and Xuehui An§

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Abstract

This paper studies the impact of centralizing deployment on teachers' effort and students achievement by exploring the reforms of rural education system in China. As regular teachers' payroll was moved from *xiang* (or school district) up to county government in 2001, the power of deployment has been gradually transfered along the same line. We exploit variations in transfer timing and use as comparison contract teachers who were not affected. Teacher data collected from Gansu province in 2000 and 2004 shows that, the increase of regular teachers' effort relative to contract teachers in *xiang*s having centralized deployment by 2003 is smaller than that where the transfer had not happened. Student test scores also had a smaller increase in centralization *xiang*s. Exploring into teacher allocation and wages suggests a likely channel: the implementation of performance pay is hindered as personnel interventions from upper-level government noises teachers performance evaluation.

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†Shorenstein APARC, Stanford University. Email: lihan@post.harvard.edu.

‡China Institute for Educational Finance Research, Peking University, Beijing, China. Email: mxliu@ciefr.pku.edu.cn

§National Center for Education Development Research, Beijing, China.

1 Introduction

Two problems plague the public school system in many developing countries: inadequate/inequitable teacher deployment and weak teacher incentive. It is often argued that the first problem can be tackled by centralizing personnel deployment;[1] and the second by instituting performance pay contract. Yet little is known on the interactions of these two policies, namely how deployment centralization affects teachers' incentive, and how they jointly determine educational outcomes. This paper explores the question in the context of rural education centralization reforms in China. We study the impacts of centralization of personnel authority on teachers' effort and affect students' academic performance. We also look for evidence on possible channels by exploring into wage structure and teacher allocation.

Practitioners and researchers have noted that the devolution of personnel deployment is critical to teacher incentive and school quality (e.g. Gaynor, 1998; Winkler and Gershberg, 2003). Yet few rigorous studies have been done in this area. In theory, centralizing deployment could affect teacher incentives in opposite directions. On one hand, centralized deployment may induce more effort by increasing job security and hence teachers' satisfaction, and improve the effectiveness of teaching by providing more professional support. On the other hand, personnel intervention from less informative upper-level government may deviate from local needs or even distort local teachers' reward structure. In reality, personnel centralization/decentralization is usually associated with other changes in the education system. The attempts to empirically evaluate the impacts of personnel centralization or decentralization often encounter identification problems. How centralized deployment affects teachers behaviors remains an unanswered empirical question.

The recent wave of centralization reform in China's rural education system has offered an unusual opportunity to study this question. In 1990s, rural primary and junior high schools (schools in the compulsory education system) were mainly financed and managed by *xiang*-level government.[2] This decentralized system is no longer sustainable in the

[1] Teacher deployment remains the responsibility of the national or regional government even in many countries where decentralization reforms have long been adopted and school finance has been devolved to community level, e.g. Kremer et al. (2003) on Kenya.

[2] The government bureaucracy largely consists of five ladders, i.e., from top to bottom, the national

late 1990s when major sources of finance - rural education fees were lifted by the national government. Therefore, the national government launched "county-based" rural education reforms in 2001. The first move is to shift regular teachers' payroll onto county government budget. While the payroll shift was completed soon, the personnel authority has also been slowly transferred along the same line.

It is documented that regular teachers' wages have been improved (Ge 2003). However, case studies suggest that deployment centralization may harm school quality through several channels (e.g. Lu 2004; Ge 2001; Zhang 2004; Bao 2007). First, proponents of centralization argue that it facilitates equitable allocation of educational resources particularly qualified teachers. Yet moving to a better location/school is part of rewards for good teachers.[3] Deploying good teachers to remote areas without proper compensation (which is often prohibited or limited by the rigid wage structure in public school system) is likely to harm their incentives directly. The second and more common channel is through the implementation of performance pay. As teaching is a team production, a teacher's performance is also affected by his/her colleagues. To make the evaluation largely comparable among schools, local educational officials need to be capable of deploying teachers. Centralization of personnel control either deprives or limits this power and hence hinders the effective implementation of incentive pay.[4] Besides the impact on incumbent teachers, the change may also lead to selection of teachers of certain characteristics into/out of the teaching profession.

To assess the impacts of deployment centralization, we draw upon two sources of data. The first source is the Gansu Survey of Children and Families (GSCF) for year 2000 and 2004. It covers detailed information of about 1,000 teachers and 2,000 students from 100 schools in 42 *xiang*s. The second one is the Gansu Survey of School Governance (GSSG), a retrospective survey collected in 2006 in the same sample schools and *xiang*s as in the

government, the provincial government, the county government, the *xiang* government and village committees. Each *xiang* government typically administers 10 - 30 villages. The population of each village is typically above 1000.

[3]School location and working conditions are also important factors in teachers mobility in developed countries, arguably more important than the level of wage (Scafidi et al. 2006, 2007; Boyd et al 2005; Podgursky 2004).

[4]Liu (2005, 2007) documents an interesting case in a county in western China: a teacher was deployed to a better school by county government when the *xiang* government was going to punish him because of poor performance.

GSCF. It contains information on school governance in year 2000, 2003 and 2005.

In identifying the role of deployment centralization on teacher effort, we exploit differences across *xiang*s in the timing of deployment power shift and make as the comparison group contract teachers who are not affected by deployment centralization. Although regular teachers' payroll had been shifted to county government in most places within two years after the launch of the reform, the transfer of deployment power was much slower as it depends upon political negotiations between *xiang* and county government. In our sample *xiang*s, less than one half had centralized teacher deployment by 2003.[5] For notational convenience, we call those *xiang*s centralization *xiang*s and others comparison *xiang*s throughout the paper. The variations in timing allow us to use the difference-in-difference (DID) method to estimate how the change in the measured effort of regular teachers from 2000 to 2004 in centralization *xiang*s differs from that in comparison *xiang*s.

Furthermore, to eliminate the effects of region-specific time-varying shocks, we use contract teachers as an additional comparison group and construct a difference-in-difference-in-difference (DDD) model. As deployment centralization only applies to regular teachers, we compare the change in the measured effort of regular teachers relative to contract teacher in centralization *xiang*s to that in comparison *xiang*s. Estimates of the DDD model are consistent with those of the DID model. The increase in weekly teaching and grading time of regular teachers versus contract teachers in centralization *xiang*s is about 3 hours lower than that in comparison *xiang*s.

Next we estimate the impact of deployment centralization on students' academic performance using the difference-in-difference (DID) approach. We find that, in centralization *xiang*s, boys' test score improvement is 0.28 standard deviation lower than that in comparison*xiang*s. Girls' test score improvement exhibits the same trend but the estimates are not statistically significant.

Why centralizing teacher deployment could be undermining? We first look for evidence by examining the allocation of teachers. There is no evidence on more equitable allocation in centralization *xiang*s. Some results even suggest the opposite. The equity-oriented

[5]According to the GSSG in year 2007, *xiang*s that have completed the transfer is nearly doubled in 2007.

allocation is not likely to be the factor driving down teachers' effort.

We further explore the regular teachers' wage structure. We find that, the wage level increased more after the reforms in centralization *xiang*s than in comparison *xiang*s; however, wages became less responsive to measures of merits such as education diploma, working hours but more responsive to seniority and job tenure. The finding suggests that the pay in centralization *xiang*s became less merit-based. Not a direct proof as it is, the result supports the hypothesis that personnel interventions from upper-level government hinders the implementation of performance pay. Survey of teachers and principals' opinion on the incentive scheme is also corroborative of this hypothesis.

Taken together, the results suggest the division of personnel power in the school system could have significant impacts on the effectiveness of implementing incentive pay and educational outcomes. Although previous studies suggest that incentive pay schemes could be a solution to the problem of low teacher effort in many developing countries, the implementation of these schemes may well require certain institutional commitment. The pre-requisite institutional settings likely affect the incentives of the implementers and hence the *de facto* implementation. Future research in this direction is merited.

The rest of this paper is organized as follows. Section 2 reviews the related literature. Section 3 introduces background information on rural education system and reforms in China. We devote much space to description of contract teachers and regular teachers because it is important to our empirical strategy and no overview exists in the previous literature. Section 4 constructs an analytical framework. Section 5 describes the data and empirical strategy. In section 6 we show results on teachers' effort and students' test scores. In section 7, we discuss and test two alternative explanations. Section 8 concludes the paper.

2 Literature Review

There is a large literature on the costs and benefits of decentralization versus centralization of public services. The main argument in support of decentralization is that the policy is more responsive to local needs as decision-making is brought closer to local citizens (Oates 1972). The channel could be through mitigating information asymmetries

over heterogeneous preferences, through improving the accountability of local service providers or/and by encouraging local participation or competition and so on (e.g. Lockwood, 2002; Besley and Coate, 2003; Besley and Ghatak, 2003; Faguet, 2004; Barhan and Mookherjee, 2005). However, decentralization may worsen the provision of public services if local governments are technically or institutionally weak, or prone to interest-group capture, or if there are positive externalities (Smith, 1985; Reinikka and Svensson, 2004; Bardhan and Mookherjee, 2005, 2006a,b).

In the case of education, empirical evidence has been accumulated on the impacts of decentralization as the practice has been increasingly adopted throughout the world. The result is mixed. Galiani et al. (2008) find positive average effects on test scores in Argentina but insignificant gains for the poor. Gertler et al. (2006) find that introducing school-based management effectively improves outcomes in Mexico. Leithwood and Menzies (1998) review 83 empirical studies of school-based management in the United States and find little evidence of positive effects on students.

Researchers have noticed that educational decentralization reforms have varied widely in their content, goals, areas of decision-making, and levels of educational responsibility (e.g. McGinn and Welsh 1999). Some have examined closely the organization structure and teacher motivation in case studies, while little empirical work has been done to disentangle the roles of several aspects of school governance structure. Some research suggests the importance of contextual issues. For example, Kremer et al. (2003) find that, in Kenya, by financing and deploying teachers at the central level but allowing local communities to start school, the system creates incentives for building too many small schools and spending too much on teachers relative to non-teacher inputs. Yet it remains unknown about the processes through which decentralization could improve student learning. This paper is an attempt to open the black box of centralization/decentralization and focus on the impacts of personnel deployment centralization on teacher incentive.

Teacher incentive is not a new issue in economics literature. Recently performance pay has gained more popularity among economists for incentizing teachers. Many studies show that implementing performance pay has a positive effect on students achievement (e.g. Lavy, 2002, 2004; Eberts, Hollenbeck and Stone 2002; Figlio and Kenny 2007; Muralidharan and Sundararaman 2006). However, only a few studies concern about the institutional environment of implementing performance pay. For example, Hanushek

(2002, 2003) points out that the reason that public schools do not implement effective performance pay is lack of competition pressure instead of ignorance of its importance. By comparing public, private and charter schools, Podgursky (2006) shows that, under decentralized systems, schools under competition pressure are more likely to adopt performance pay. In many developing countries, school choices are limited because of political or economic constraints reasons. Thus the division of power may be more likely to affect the constraints or incentives for the implementers. However, it has been rarely studied in the development settings. The evidence in this paper contribute to this strand of the literature.

3 Background

3.1 The Evolution of Rural Education System

The rural primary and secondary school system in China is separate from the urban one. Since the strict implementation of household registration (*hukou*) system in late 1950s, people have been tied to places where they were issued hukou card (usually their or their parents' birthplace). Rural-to-urban migration is tightly controlled. The *hukou* is linked to employment opportunities and access to local public services such as education and health care. School choices between *xiang*s are typically either limited by poor public transportation or restricted by national or local policies.[6] Choices within *xiang*s may be allowed in some places. However, the distance among schools often limits choices. The supply of private schools is scarce, especially in economically disadvantaged regions.[7]

The segregation and various urban-biased polices have created enormous disparity in education. Rural public schools typically suffer from lack of funding and qualified teachers. The disparity had been entrenched after the *Compulsory Education Law* passed in

[6]The national bureau of education holds a negative attitude towards school choices. In various documents and speeches, high-level education officials continuously labeled school choice as "illegal" and blamed it for bidding up school fees and entrenching inequality in education opportunities.

[7]Private schools at the mandatory education level are discouraged by the national policy. In poor areas, parents usually can not afford to send kids to private schools.

1986.[8] The law specified a decentralized compulsory education system where local governments take most administrative responsibilities. It is also stipulated that school finance be provided by each level of government (namely, the national government, provincial government, county government and *xiang* government in rural areas) by proportion and by category. However, division of responsibilities was never clearly specified, especially for rural schools. Most of financial burdens eventually fell upon *xiang* government. From 1995 - 1999, among all the fiscal input by each level of government in rural compulsory education system, the input by the state government only accounted for $1.5\% - 2\%$; the provincial government fiscal input accounted for about 11%; *xiang* government input accounted for around 85%.[9]

The major source of funding used by *xiang* government in school finance was fees collected from peasants in the name of "education fee" and "education fee plus".[10] Regular teachers' payroll was on *xiang* fiscal budgets. Schools had certain flexibility in charging tuitions, which made up for the major part of non-payroll recurrent expenses.[11] Upper-level governments typically only allocated funds for school renovation and building.

Under this decentralized system, the authority of personnel management was largely held by *xiang* education office. County education offices hired regular teachers based upon each *xiang*'s demand. The *xiang* educational office deploys teachers to schools as well as paying them out of fiscal budget. As the *xiang* government controled regular teachers' payroll, it had strong bargaining power in the decision of hire, deploy and transfer teachers. County government had little say in such decisions. *Xiang* education offices were also responsible for assessing teachers' performance. Regular teachers are generally paid according to a standardized grid that translates variables such as experience, education, performance and rank into pay levels. The standard is set by each *xiang* educational office.

[8]The Law designates 9 years of compulsory schooling, that is, it requires parents to have their children finish primary and junior high school education.

[9]source

[10]The *State Council Decree on Rural School Funds Raising* enacted in 1985 awarded the *xiang* (or town) government the authority to collect the two types of fees from local firms and households. Approval being needed from county government, the *xiang* government set the amount or rate. The education fee plus charged on household is usually set as a proportion (about $1\% - 3\%$) of the *xiang* pure income per capita in the previous year.

[11]School affiliated firms could also generate some revenues to cover certain expenses in some places.

In places short of regular teachers, contract teachers[12] are also hired. The hire decision is usually made by *xiang* or villages as well as schools. We will reserve the discussion of two types of teachers to next subsection.

The source of fiscal revenue in many *xiang*s dried up in late 1990s when the state government implemented a taxation reform to lift various taxes and fees including education fees and education fee plus and to limit the tax authority of local officials. Rural education system was hit hard. To ensure normal operations of the system, the state government initiated the "county-oriented" reforms in 2001 and shifted regular teachers' payroll onto county fiscal budget.[13] In principle, the power of personnel management should be shifted to county education offices accordingly. Yet the shift of personnel power depends on political negotiations between *xiang*-level government and county government. As financial centralization has been almost completed by 2003, the personnel power shift is much more slow. In our sample of 50 *xiang*s, only 24 have seen the power shift by 2005.

3.2 Regular Teachers Versus Contract Teachers: Incentives and Deployment

The job of regular teachers is considered as one of the most attractive options in rural areas. The pay level is well above the average rural income. Moreover, they are treated as government employees and can not be fired except in extreme cases. They were on the payroll list of the *xiang* government before the centralization reform in 2001 moved their payroll onto the county government fiscal budget. Regular teachers are hired from the pool of graduates from local government-run teachers' college.[14]

However, regular teachers typically fall short in rural areas, especially in remote villages. There are two reasons for the shortage: first, regular teachers' payrolls are heavy financial burdens for local governments; second, regular teachers are reluctant to work in

[12] explain the name

[13] cite document

[14] Most counties have its own government-run teachers' schools. Students are admitted from junior high school graduates. They are the primary source of rural regular teachers. Upon graduation, they are assigned by county education offices to each *xiang*. The main principal of the allocation is the graduate's hometown and the *xiang* education office's demand.

remote villages, and the rigid wage structure does not provide enough compensation for tough working conditions. So villages and *xiang*s short of teachers seek to hire contract teachers among local residents. The expense is shouldered by villages and/or *xiang*s. Contract teachers are likely to be villagers who have above-average schooling but fail to be admitted into colleges. So they tend to have lower educational attainment than regular teachers.

Although the pay is only about one quarter of that of regular teachers, being a contract teacher is still a good option to rural residents. Both the absolute income level and returns to education in rural jobs (both on-the-farm and off-farm jobs) are low.[15] Working in urban areas without urban hukou is usually associated with hardships and discrimination. In contrast, contract teachers do not have to endure pains of being away from family. Moreover, in many places there are chances for them to become regular teachers on the condition that they are recommended by schools and pass certain qualification exams.

Regular teachers' and contract teachers' pays differ not only in levels and sources, but also in the structure. The pay of contract teachers is lump-sum. Some may have a small increase with teaching load. It does not vary much by tenure or other qualification. Regular teachers' salary usually consists of two parts: basic wages and bonuses. The level of basic wages is determined by teachers' professional title (zhi cheng), job tenure and so on, and financed by the local government. Bonuses are awarded by schools or *xiang* educational offices to those whose students have exceeding performance. The source of bonus is typically from the budget surplus of schools or *xiang* educational offices. In some places without surplus, *xiang* educational offices or schools cut a small proportion from every regular teacher' wages and use it to reward those with good performance in the yearend. As most rural schools are plagued by shortage of funding, the size of bonuses is small relative to that of wages. So higher professional titles are most sought after by regular teachers. The grant of professional titles is based upon one's tenure, qualification like diploma or teacher certification, year-end performance evaluation and publication etc. The level of basic wage for each title has no variation across towns in the same county. But The criterion vary by *xiang*s and over time.

Despite low and flat pay, contract teachers have strong incentives to work hard. First,

[15] number. reference

they may lose the job in case of unsatisfactory performance. School principals and local educational officers all have the power to fire them. Second, they have chances to pass the exam and to become a regular teacher. The county education bureau usually solicit their schools' comments. Good school evaluations are as important as test scores in the decision process.

As the source of pay differs between regular teachers and contract teachers, the school finance reform has different impacts on them. The employment/deployment and pay of contract teachers remains the decision made by *xiang* or villages as contract teachers are considered as "outside-of-the-system" and not belonging to the formal personnel. In contrast, regular teachers are subject to the power shift of personnel management caused by the reforms. The power of in-town teacher deployment is the primary goal that *xiang* and county are fighting for.The result of the fight depends on many factors in the political bargaining process instead of teacher performance.[16]

4 Analytical Framework

In the introduction, we gave an intuitive version of what could happen to teachers' incentive under centralized deployment. This section presents a formal exposition of the predictions in a simple moral hazard model with deployment decision and team influence.

To begin with, we consider a *xiang* with two schools, indexed $i \in \{1, 2\}$ and two new teachers, indexed $j \in \{1, 2\}$. Schools differ in teaching environment. Teachers differ in their ability of benefiting from the teaching environment. As the principal, the *xiang* educational official deploys new teachers to schools and chooses a contract to motivate the agents - teachers. The teacher supplies an effort e at a cost $c(e) = e^2/2$. Effort is unobservable and hence non-contractible. Educational outcome is of two possible levels, high ($Y^H = 1$), or low ($Y^L = 0$).

Both the *xiang* educational official and the teacher are risk neutral. The limited-liability constraint is assumed so that the moral hazard problem has bite. That is, we assume that the teacher have no wealth that can be pledged as performance bond.

[16] elaborate on this point.

Thus, the teacher has to be given a minimum consumption level of $\underline{\omega} \geqslant 0$, irrespective of performance. We assume that the *xiang* educational official has sufficient resources to finance any required salary package and that his reservation utility is zero. We also assume that the principal must make a non-negative payoff.

The types of schools and teachers are perfectly observable to the *xiang* educational official. He assigns teachers to schools. School i matched with teacher j receives a payoff $\pi_{ij} > 0$ if educational outcome is high ($Y_H = 1$) and 0 otherwise. Teacher j matched with school i receives an efficiency gain of $\theta_{ij} > 0$. The probability of high educational outcome is equal to the effort supplied by teacher j in school i plus her efficiency gain θ_{ij}, i.e. $Prob(Y_{ij}^H = 1) = e_{ij} + \theta_{ij}$. We denote the assignment decision as $\mathbf{F}$. There are two assignment schemes, indexed by $\mathbf{F_1}$ and $\mathbf{F_2}$ respectively. Assignment $\mathbf{F_1}$ matches a school with the same type of teacher, i.e. $\mathbf{F_1} : i = j, i \in \{1, 2\}, j \in \{1, 2\}$; Assignment $\mathbf{F_2}$ matches a school with a teacher of different type, i.e., $\mathbf{F_1} : i \neq j, i \in \{1, 2\}, j \in \{1, 2\}$.

Assumption 1. $\pi_{11} \geqslant \pi_{22}$ and $\theta_{11} \geqslant \theta_{22}$ and $\pi_{12} = \pi_{21} = \underline{\pi}$.

Contracts between principals and agents have two components: a fixed wage ω, which is paid regardless of the educational outcome, and a bonus b, which the agent receives if the outcome is Y_H. The contract that picked by the principal applies to both schools. The principal cannot design one contract for each school. This is a realistic assumption.[17]

The *xiang* educational official's optimal contracting problem with decentralized deployment solves

$$\max_{\{b,\omega,\mathbf{F}\}} \sum_{i,j} u_{ij}^p = \sum_{i,j} (\pi_{ij} - b)(e_{ij} + \theta_{ij}) - 2\omega \tag{1}$$

subject to the following constraints.

1. *Limited liability constraint (LL)* , requiring that the agent be left with at least $\underline{\omega}$:

$$b + \omega \geqslant \underline{\omega}, \ \omega \geqslant \underline{\omega} \tag{2}$$

[17]In theory, the *xiang* educational official can design a contract for each school. However, it is not realistic in practice. The school-contigent contract gives the *xiang* government too much flexibility and hence too less transparency. It likely causes the opposition of school principals and teachers.

2. *Participation constraint (PC)* of the agent:

$$u_{ij}^{a} = (e_{ij} + \theta_{ij})b + w - \frac{1}{2}e_{ij}^{2} \geqslant \bar{u}_{j} \tag{3}$$

where $\bar{u}_j$ is the reservation utility of teacher j.

3. *Incentive-compatiility constraint (IC)*, which stipulates that the effort level maximizes the agent's private payoff given (b, w):

$$e_{ij} = \arg\max_{e_{ij}\in[0,1]} \left\{(e_{ij} + \theta_{ij})b + w - \frac{1}{2}e_{ij}^{2}\right\} \tag{4}$$

We restrict attention to the range of reservation payoffs for the teacher in which the *xiang* educational official earns non-negative payoffs. The *IC* constraint can be simplified to

$$e_{ij} = b \tag{5}$$

The *xiang* educational official's problem can be broken into two steps. First, at any given assignment, we can solve for the optimal contract. Second, the assignment $\mathbf{F}^*$ that yields the greatest utility of the principal is chosen.

We first look for the optimal contract under given teacher assignment. Without loss of generality, we work with the case where $\underline{\omega} = 0$. The following argument characterizes the optimal contract under different assignment schemes.

Proposition 1. Suppose that $\pi_{ij} + \theta_{ij} < 1$. An optimal contract (b_s^*, ω_s^*) under assignment scheme s given a reservation payoff $\bar{u}_j \in [0, (\pi_{ij} + \theta_{ij})^2/2]$, exists and has the following features.

1. The fixed wage is set at the subsistence level: $\omega_s^* = 0,\ s \in \{1, 2\}$.

2. The bonus payment under assignment $\mathbf{F_1}$ is characterized by

$$b_1 = \begin{cases} \max\{0, Y_1\} & if\ \bar{u} < \frac{1}{2}\{Y_1\}^2 + Y_1\theta_{22} \\ \sqrt{2u + \theta_{22}^2} - \theta_{22} & if\ \bar{u} \leq (\pi_{11} + \pi_{22})^2/4 + \pi_{11}\theta_{11} + \pi_{22}\theta_{22} \end{cases}$$

where $Y_1 = \max\{0, (\pi_{11} + \pi_{22} - \theta_{11} - \theta_{22})/4\}$.

The bonus payment under assignment $\mathbf{F_2}$ is characterized by

$$b_2 = \begin{cases} \max\{0, Y_2\} & if\ \bar{u} < \frac{1}{2}\{Y_2\}^2 + Y_2\underline{\theta} \\ \sqrt{2u + \underline{\theta}^2} - \underline{\theta} & if\ \bar{u} \leq (\pi_{12} + \pi_{21})^2/4 + \pi_{12}\theta_{12} + \pi_{21}\theta_{21} \end{cases}$$

where $Y_2 = \max\{0, (\pi_{12} + \pi_{21} - \theta_{12} - \theta_{21})/4\}$.

3. The optimal effort level is given by $e_s^* = b_s^*$. The expected educational outcome is $e_s^* + \theta_{ij}$ for teacher j in school i.

For the sake of illustration, we focus on the case where $\pi_{ij} > \theta_{ij}$ and the PC is not binding. We also simplify the calculation by taking the following assumption.

Assumption 2: $\theta_{11} = \theta_{21} > \theta_{12} = \theta_{22}, \pi_{11} - \pi_{12} \neq \pi_{21} - \pi_{22}$.

If $\pi_{11} - \pi_{12} > \pi_{21} - \pi_{22}$, the optimal assignment is $\mathbf{F_1}$;[18] the optimal contract is $b_1 = (\pi_{11} + \pi_{22} - \theta_{11} - \theta_{22})/4$, which is greater than b_2. If $\pi_{11} - \pi_{12} > \pi_{21} - \pi_{22}$, the optimal assignment is $\mathbf{F_2}$; the optimal contract is $b_2 = (\pi_{12} + \pi_{21} - \theta_{12} - \theta_{21})/4$, which is greater than b_1. Recall that $\pi_{ij} - \theta_{ij}$ measure school i's benefit relative to teacher j's gain from assigning teacher j to school i if educational outcome is high. Therefore, the above result implies that, the optimal assignment for the *xiang* government is the one that yields the maximum net gains. Under this assignment, the *xiang* government is also able to use relatively high-powered incentives to motivate teachers.

The essence of this simple framework is that the choice of contract hinges on the assignment of teachers. Under centralized deployment, the *xiang* educational official is able to chooses the combination of assignment and contract that yields maximum gain. Now consider the case where the county government takes over deployment authority. The *xiang* educational official takes the deployment decision as given and picks the optimal contract. If the assignment scheme chosen by the county government deviates from the above $\mathbf{F}^*$, the optimal contract picked by the *xiang* educational official is likely to deviate from b^*. We denote the assignment scheme and contract chosen under centralized deployment is $\mathbf{F_c^*}$ and b_c^* respectively. Under assumption 2, it is easy to show that $b_c^* < b^*$ if $\mathbf{F_c^*} \neq \mathbf{F}^*$.

Let's consider two possible cases where the shift of deployment authority may affect teacher incentive. The first case is that the county government has different objectives from the *xiang* educational official. Whether being more or less equity-oriented, the county government may prefer the assignment scheme that is different from the optimal one under decentralized deployment. For example, suppose the assortative matching $\mathbf{F_1}$

[18] It is similar to the condition for assortative matching.

is the optimal assignment for the *xiang* educational official. Yet the county government cares more about the equitable allocation of teachers across school. So scheme $\mathbf{F}_2$ is adopted. Given this assignment, the optimal contract for the *xiang* educational official is b_2, which is smaller than b_1. The effort induced by this contract and the overall educational outcome is also lower than that under decentralized deployment. Under assumption

A more interesting scenario is documented in field studies (Liu 2007). The *xiang* educational official found the overall educational outcome is higher when the teaching resource was roughly balanced among schools. However, when the county government assumed the deployment authority, it tipped the balance by assigning good teachers to schools close to the county government. Consequently, the *xiang* educational official had to flatten the wage contract so as not to hurt the incentives of teachers assigned to remote schools. That is, if $\pi_{11} - \pi_{12} < \pi_{21} - \pi_{22}$, the *xiang* educational official obtains the maximal net gains by matching teachers with different types of schools. When assortative matching $\mathbf{F_1}$ is adopted, for the *xiang* educational official, the marginal benefit of inducing one extra unit of effort is lower, therefore, the optimal bonus b should be lower.

The two examples show how personnel interventions from the upper level government, well-meant or not, might weaken teacher incentives. The reason is that the intervention from upper level government hinders the *xiang* educational official from exploiting the gains of matching teachers to schools and limits its power to motivate teachers.

The second case is that the county government has the same interest as the *xiang* government, i.e. he plans to adopt the assignment scheme that preferred by the *xiang* educational official. However, the county government is less informative on teachers. In theory, the county government and the *xiang* educational official can share all the information. However, it is not feasible in reality because of the large number of teachers in each county. Moreover, it may cause other sorts of incentive problems such as collusion etc.[19] It is beyond the scope of this paper. Here we take it as given and illustrate the impact. For example, in the case where $\mathbf{F_1}$ is the optimal contract, the county government has a probability p to mistake type 1 teacher for type 2 teacher ($0 < p < 1$). So for *xiang*

[19] reference

educational official, the optimization problem becomes

$$\max_{b,w} \ (1-p)\sum_{i=j}(u_{ij}-b)(e+\theta_{ij})+p\sum_{i\neq j}(u_{ij}-b)(e+\theta_{ij})-2\omega \tag{6}$$

The optimal contract under county deployment is $b_c^* = (1-p)b_1 + pb_2$. Under assumption 1 and 2, $b_c^* < b^* = b_1$. This result is quite intuitive. If the uncertainty on deployment decision increases, the *xiang* educational official tends to pick a relatively low-powered incentive contract so as not to hurt teachers' incentive. Consequently, teachers' effort declines, i.e. $e_c^* = b_c^* < e^*$.

We show the interaction between deployment decision and contract choice through the analysis of the above two cases. The centralization of deployment power limits the *xiang* educational official's choice of optimal contract. It may result in the decline of teacher effort and educational outcome. In the subsequent sections, we will examine empirically the impact of deployment centralization on teachers and students.

5 Data and Identification

5.1 Data

The data used in this paper draws upon two sources. The first is the first two waves of Gansu Survey of Children and Families (GSCF).[20] The first wave was conducted in 42 *xiang*s in 20 counties in Gansu in 2000. The survey randomly sampled 2,000 students aged from 9 to 12. Detailed information was collected regarding their parents, villages, schools and homeroom teachers. Randomly selected teachers from their schools were also surveyed regarding their workload, work conditions, salaries and so on. The second wave of the survey was conducted in 2004 and the same sample of students was followed. Similar and more detailed survey was also run on schools, villages, parents and teachers. Although the same sample of students were followed, teachers surveyed can be different from those who appeared in the first wave. Thus we construct a panel of student

[20]The GSCF is a longitudinal survey conducted in Gansu, one of the poorest provinces in western China. More detailed information on this survey is available at the project website: http://china.pop.upenn.edu.

data and take the teacher data as two waves of cross-sectional data in the teacher-level regressions.

The second source of data draws upon the Gansu Survey of School Governance - a retrospective survey collected in 2006 covering the same sample schools and *xiang*s as in the GSCF plus 8 additional *xiang*s (50 *xiangs* in total). The survey has two tiers: school-level and *xiang*-level. It covers information on two major aspects of school governance structure – school finance and personnel management in year 2000, 2003 and 2005. A follow-up survey was conducted in 2007. Detailed information on the survey is in appendix A. Summary statistics on personnel authority is listed in table 2. By mid 2003 – two years after the reform was launched, almost all *xiang*s have transferred regular teachers' payroll. However, the transfer of personnel management is more slowly. By 2003, only 30% have transfered the power of teacher deployment to the county government. By 2005, the number increased to more than one half.[21]

We combine these two sources of data together and divide the 42 *xiang*s into two groups: those with centralized teacher deployment by 2003 (labeled as the centralization group) and those without (labeled as the comparison group). Table 4 summarizes the pre-reform characteristics of xiangs and schools by group and the differences. Concerned that the small sample may raise the issue of small power, we also estimate the t statistics by bootstrap methods. It does not differ much from original t-statistics. Most variables are balanced between the two groups. The average distance between two closest school in the same *xiang* is about 20 kilometers, of which about 9-12 kilometers is mountainous roads. *xiang*s in the centralized group tend to be closer to county government. The difference is significant at 10%. The size of primary schools in the sample are small on average, which is typical for rural primary schools. Schools in centralization *xiang*s tend to be larger according to the estimated means. Yet the differences are not statistically significant. The average number of students per school is around 240 in schools in comparison *xiang*s while it is about 290 in centralization *xiang*s. The number of regular teachers per school in comparison *xiang*s is about 8 while schools in the comparison *xiang* has slightly more regular teachers - the mean number is about 11. The mean numbers of contract teachers are both about 2.5. The number of classrooms is about 16 - 18. To summarize, centralization *xiang*s and comparison *xiang*s are quite similar in most aspects, except

[21]Explain the political negotiations between *xiang* and county government.

that centralization *xiang*s tend to be closer to the county government.

Next we look at summary statistics of teachers by group presented in table 5. Column (1) and (2) list pre-reform characteristics of regular teachers in centralization and comparison *xiang*s respectively. Column (3) presents differences between the two groups. The weekly time of teaching is around 13 hrs and does not differ between groups. The sampled regular teachers in centralization *xiang*s are slightly older and more experienced in teaching than their counterparts in comparison *xiang*s. The difference in both ages and time of teaching is about 1.9 years. Regular teachers in centralization *xiang*s tend to have lower educational degree. About 78% only have diploma from primary schools or junior high schools. 18% have diploma from senior high schools or equivalent. In contrast, about 27% of regular teachers in comparison *xiang*s have diploma from senior high schools or equivalent.

Post-reform characteristics of regular teachers in centralization and comparison *xiang*s and the differences are listed in column (4) - (6) respectively. The weekly teaching time of regular teachers in centralization are 1.8 hours less than those in the comparison group while age, job experience, educational diploma generally exhibit similar patterns to that in pre-reform period (though differences are statistically insignificant).

Column (7) - (12) show pre- and post-reform summary statistics of contract teacher by group. Contract teachers in centralization *xiang*s are similar to those in comparison *xiang*s in terms of age, job experience, education attainment. Compared to regular teachers, they are younger (the average age is 29 years old), less experienced (the average time of teaching is 7.7 years) and less educated (only around 10% have graduated from senior high school or equivalent). Before the reform, contract teachers in comparison *xiang* taught for the same length of time as regular teachers. Contract teachers in centralization *xiang*s taught 1.7 hours more weekly than those in comparison groups before reforms and slightly less than regular teachers in centralization *xiang*s. Yet in the post-reform period, contract teachers in centralization *xiang*s teach 2.15 hours more than those in comparison *xiang*s and about 4 hours more than regular teachers in centralization *xiang*s.

Summary statistics of students to be added.

5.2 Identification

This subsection outlines the identification strategy. To isolate the causal role of the incentive effect of centralizing teachers deployment resulting from the reform, we make use of differences across *xiang*s induced by the timing of the reform and differences between regular teachers and contract teachers in the influence of the reform.

We first specify the benchmark difference-in-difference (DID) model, in which we compare the change in regular teachers' effort and student educational outcomes from 2000 to 2004 in centralization *xiang*s to that in comparison *xiang*s. The specification is as follows.

$$Teacher\ effort_{isrt} = \alpha_0 + \alpha_1 T + \alpha_2 post + \boldsymbol{\alpha_3} \cdot T \cdot post + X_{it}\Omega_1^1 + Y_{st}\Omega_2^1 + Z_{rt}\Omega_3^1 + \epsilon_{isrt} \quad (7)$$

$$Student\ outcome_{jsrt} = \beta_0 + \beta_1 T + \beta_2 post + \boldsymbol{\beta_3} \cdot T \cdot post + M_{jt}\Omega_1^2 + Y_{st}\Omega_2^2 + Z_{rt}\Omega_3^2 + \eta_{jsrt} \quad (8)$$

where $teacher\ effort_{isrt}$ is measured with self-reported weekly teaching and grading hours of teacher i in school s in *xiang* r in year t; $Student\_outcome_{jsrt}$ is measured test scores of student j in school s in *xiang* r in year t. *post* is a dummy for time, $post = 1$ if year 2004 and $= 0$ if year 2000. T is the indicator for the centralization group, $T = 1$ if centralization *xiang*s; $= 0$ if not. We also include school s's characteristics Y_{st} and *xiang* characteristics Z_{rt}. In addition the teacher effort regression 7 controls for teacher i's characteristics X_{it} including gender, age, teaching experience (years of teaching and years of teaching in this school); the student outcome regression 8 controls for students' characteristics M_{jt}.

In equation (7), we restrict our sample to regular teachers because only they are affected deployment power shift. The DID approach excludes the time-invariant endogenous factors. One concern about this approach, however, is that the error terms might be correlated across time and space. We allow for such correlation by computing our standard errors clustered by first at the *xiang* level, then at *xiang*-year level and then again at the school level. The statistical significance of our estimates does not change when assessed using the three alternative ways of clustering standard errors.We only report standard errors adjusted by clustering at the *xiang* level in next section because it is the most conservative estimate.

One of the major threats to the validity of our identification strategy is that there may be omitted non-common time-varying factors that are correlated with both centralizing teacher deployment and test scores. There are two ways in which this might happen. The first is the endogeneity of the timing of teacher deployment transfer. This would occur if government's choice of where and when to centralize are based upon teachers effort/educational outcomes or on local shocks correlated with teachers effort/educational outcomes. In other words, the county government could have purposively based its personnel centralization on local-specific time-varing information.

In our case, bias from endogenous timing of personnel centralization is not likely to be an issue. The county-based reform is a national policy that applies to all rural schools. While financial control was stipulated to be transfered in a limited period, the transfer of personnel control depended on political negotiations between the *xiang* government and the county government[22] and not on test scores or teachers effort level. The previous subsection also shows that the observed pre-reform teacher and student characteristics are not significantly different between two groups. It provides empirical evidence against the most obvious sources of endogenous timing of deployment power shift: those related to teachers and students. We also have included as many as possible time-varying variables as controls to take care of this issue.

The second way in which omitted time-varying factors could confound the analysis is if there were other local-specific time-varying policies or environmental factors that affect treatment observations differently than control ones. We address this concern by using contract teachers as another control on which to base the conclusions about the impact of regular teachers' deployment centralization. As discussed in section 3.2, changes in deployment power do not apply to contract teachers. They remain hired and deployed by local communities or schools. Therefore, by comparing changes in regular teachers' effort with contract teachers' effort, we could get rid of the confounding effects of other local-specific time-varying factors. The DDD model is specified as follows.

$$\begin{aligned} Teacher\ effort_{isrt} &= \gamma_0 + \gamma_1 T + \gamma_2 post + \gamma_3 F_i + \boldsymbol{\gamma_4} \cdot T \cdot post + \boldsymbol{\gamma_5} \cdot T \cdot F_i \\ &+ \boldsymbol{\gamma_6} \cdot post \cdot F_i + \boldsymbol{\gamma_7} \cdot T \cdot post \cdot F_i + X_{it}\Omega_1^3 + Y_{st}\Omega_2^3 + Z_{rt}\Omega_3^3 + \mu_{isrt} \end{aligned} \quad (9)$$

where F_i is an indicator for teacher i being a regular teacher. The regular teacher in-

[22] reference needed

dicator F_i is interacted with the time dummy T and centralization indicator D, which provides us with the DDD estimate of the impact of deployment centralization on regular teachers' effort. While the characteristics of contract teachers may systematically differ from that of regular teachers, identification of treatment effect will be robust as long as this difference has a constant trend across treatment and control schools. To address the possibility that it is not, we control for a large set of observable individual characteristics.

Unfortunately, for students outcome regression, we are not able to construct such a DDD model because students are usually taught by a combination of regular teachers and contract teachers. However, comparing changes in students achievement across groups give us a hint on the overall impact of deployment centralization on school quality.[23]

6 Effect of personnel centralization on teacher hours

The estimates of teacher effort regression is displayed in table 6. Column (1) and (2) present results of DID model specified in equation (7), separately estimated for regular teachers and contract teachers. Column (3) and (4) list estimates of the DDD model specified in equation (9) with county dummies and without county dummies respectively. All standard errors are clustered at the *xiang* level. Teachers' personal characteristics (gender, age and its square term, educational diploma, years of teaching and years of staying in the surveyed school) are controlled for in all columns. The demographic variables likely capture a portion of the impact of changing teachers composition that influences the effort gap between regular and contract teachers. Time-varying school characteristics such as teacher-to-student ratios and the number of classrooms are also controlled for in each specification.

The estimates of the DID model helps to clarify the story. Column (1) reports the results estimated using the sample of regular teachers. The positive and statistically significant coefficient of time dummy (*post*) shows that regular teachers in comparison *xiang*s increased weekly teaching and grading hours by about 4 hours from 2000 to 2004. However, the increase in centralization *xiang*s is about 2.5 hours lower. The

[23]We probably could find whether kids' homeroom teachers are teachers or contract teachers. try this.

result indicates the negative effect of deployment centralization on regular teachers' effort. To know whether it is likely caused by *xiang*-specific time-varing shocks, we need to look at whether contract teacher who are not affected by this centralization exhibits the same pattern. As shown in column (2) of table 6, the pattern for contract teachers is different. The weekly working time also increased by about 3.1 hours (though statistically insignificant) in the comparison group. However, the positive effect (though statistically insignificant) of the interaction between time dummy (*post*) and group dummy (T) shows that the increase in contract teacher hours is even bigger in centralization *xiang*s than that in comparison *xiang*s. The contrast between regular and contract teachers shows that centralized deployment may lead to shorter working time of regular teachers after taking into account other environmental shocks.

The impact of deployment centralization can be seen more clearly from the estimates of the DDD model listed in column (3) and (4) of table 6. Among the main effects, only the centralization indicator (T) has significantly positive effects. It shows that teachers in centralization *xiang*s were on average working for 2-3 hours longer every week than those in comparison *xiang*s in 2000. The second-degree interactions, which control for group-specific time-varying factors generally do not have statistically significant effects. Particularly the interaction between the indicator for centralization (T) and the indicator for regular teachers ($I(regular\ teacher)$) captures whether the pre-reform gap in working hours between regular and contract teachers differ between treatment *xiang*s and comparison *xiang*s. The negative and insignificant sign of the coefficient on this interaction shows that the pre-reform working hour gap between teachers does not differ much between the two types of *xiang*s.

The key variable of interest is the third-degree interaction of the centralization indicator (T), time dummy (*post*) and the indicator for regular teachers ($I(regular\ teacher)$). The coefficient of this variable measures how the change of the gap in working hours between regular and contract teachers in centralization *xiang*s differs from that in comparison *xiang*s. The estimates for model including county dummies (column (3)) show that, compared to contract teachers, the increase in regular teachers' working hours in centralization *xiang*s is 4.1 hours lower than that in comparison *xiang*s. The effect is stronger if no county dummies included.

To summarize, the average weekly working hours of regular teachers seems to have

increased from 2000 to 2004. As similar changes can be seen in contract teachers, it is likely to be caused by region-sepecific factors. However, the increase for regular teachers in centralization *xiang*s is about 50% lower than that in comparison *xiang*s. Shorter working hours suggests that regular teachers reduce their effort after the deployment was centralized. However, shorter hours may mean that the efficiency of teaching has been improved. To distinguish the two explanations, we need to further look at the measures of education quality such as student test scores. Section 8 will show the results.

6.1 Robustness check

A concern is that the secular trend in towns where teacher deployment has been centralized could be different from the secular trend in towns where teacher deployment. If true, then the change in the regular teachers' effort in towns where teacher deployment has not been centralized by 2003 would not be an unbiased estimate of the counterfactual – i.e. what would have happened to towns with teacher deployment has been centralized by then if the transfer of personnel control had not happened.

A subset of teachers in our data have been surveyed in both 2000 and 2004. We examine changes in the working hours using this sub-sample. Details to be added.

7 Students' academic outcomes

This section examines the impact of centralizing teachers deployment on students' academic performance.

As test scores have a strong persistent component, the precision of the estimated treatment effect can be increased substantially by controlling for a child's pre-treatment test score and cognitive score. Since the attrition is low and the treatment is not likely to be based upon students' scores, the point estimates should be similar to the simple differences in the standard DID specification, but the confidence interval around these point estimates should be much tighter.[24] The panel structure of the student data allows us to use an alternative specification which regresses the change in a student's test score

[24] reference

(post-test score minus pretest score) on the treatment status of the child's *xiang* (T), controlling for the pre-test score of child i in *xiang* r. Since the treatment effect could be heterogenous to students with different pretest score, we also include the interaction between T and the pre-test score. Other control variables include *xiang* characteristics (distance from county government, distance between two closest schools and dummies for mountainous areas) and parents' years of schooling. The regression specification can be written as follows.

$$y_{ir}^{POST} - y_{ir}^{PRE} = \lambda + \delta T + \theta y_{ir}^{PRE} + \rho T * y_{ir}^{PRE} + \epsilon_{ir}^{POST} \tag{10}$$

where y_{ir}^{POST} and y_{ir}^{PRE} are the standardized test score of child i in *xiang* r in 2000 and 2004 respectively. This specification asks whether children improved more relative to what would have been expected based on their pre-test score in centralization *xiang*s than in comparison *xiang*s. Table 7 presents the results, estimated separately for boys and girls. We restrict the sample to children below 12 years old in 2004 because they stayed in the primary schools during the period 2000 - 2004 and were affected by the centralization. All standard errors are clustered at the *xiang* level.

Column (1) and (2) display the results of Chinese language and math standardized test scores respectively for boys. The average improvement of Chinese language test scores in centralization *xiang*s is similar to that in comparison *xiang*s on average. However, as suggested by the significantly negative sign of the interaction between the indicator for centralization group (T) and pre-test scores, boys with higher pre-test scores were hurt by the centralization. The impact of centralization is negative on boys whose pre-Chinese scores are more than 0.12 standard deviation above the average. The improvement for boys with pre-Chinese scores 1 standard deviation above the average is about 0.16 standard deviation lower in centralization *xiang*s than that in comparison *xiang*s. The negative effects on boys' math scores are stronger. On average the improvement of math scores in centralization *xiang*s is 0.3 standard deviation lower than that in comparison *xiang*s. Boys with higher pre-math scores are probably hurt more, though the difference is not statistically significant.

Column (3) and (4) reports the results of Chinese and math standardized test scores respectively for girls. The effects of centralization on girls' test scores are not statistically significant. Yet the impact is similar to that on boys'. Both suggests that the centralization of deployment affects students' learning negatively.

8 Why Centralized Deployment Could Be Undermining?

The results in section 6 and 7 show that deployment centralization tends to undermine teachers' incentive and educational outcomes. The analysis in section 3 shows that the channels could be direct and indirect. The direct channel that is often used as argument supporting centralization is that the allocation of teachers is more equitable under centralized deployment; however, it hurts teachers' incentive by assigning qualified teachers to schools with poor conditions. An alternative channel is through the implementation of incentive pay: *xiang* educational officials' ability to reward teachers based upon their performance was limited because the centralized deployment creates more uncertainty. The deployment power shift may also lead to the changes in the composition of teachers as teachers of different characteristics may opt out or into the teaching profession.

In our empirical analysis, the selection of teachers is unlikely to play a major role though its role is probably bigger in the long term. As mentioned before, new teachers are mainly hired among graduates of local teachers' schools. Most of them were already enrolled in those schools when the reform began. Upon graduation, they do not have strong incentive to switch to other professions for several reasons: first, teaching is still the most attractive option for rural students; moreover, the teacher job was almost guaranteed at that time while there is huge uncertainty if one gives up the assigned job and looks for other jobs. In the rest of this section, we will look for evidence on the first two channels by examining the allocation of teachers and their wage structure.

8.1 Is allocation of teachers more equitable under centralized deployment?

If centralization of personnel deployment helps to achieve equity, we should observe that schools with poor conditions in centralization *xiang*s have seen more improvement in terms of teachers' quality/quantity than their counterparts in comparison *xiang*s. Therefore, we estimate how the changes in various measures of teacher-student ratio across schools with different pre-conditions differ between centralization and comparison

*xiang*s. The regression for estimation is specified as follows.

$$\Delta Y_s = \alpha_1 T + \alpha_2 Y_s^{PRE} + \alpha_3 T \times Y_s^{PRE} + X\beta + \mu_s \tag{11}$$

Where $\Delta Y_s = Y_s^{POST} - Y_s^{PRE}$; Y_s^{PRE} and Y_s^{POST} are pre- and post-reform measures of teacher-student ratio. We are interested in four measures: total-teacher-to-student ratio, regular-teacher-to-student ratio, contract-teacher-to-student ratio, and college-educated-teacher-to-student ratio. T is the treatment dummy, $T = 1$ if centralization *xiang*s; $= 0$ otherwise. X is the matrix of control variables including the number of students and its square, the number of classrooms, distance from the nearest school, distance from county government and county dummies.

In specification (11), we are particularly interested in α_1 and α_3. α_1 measures how the increase in average teachers input differs between centralization *xiang*s and comparison *xiang*s. α_3 captures the effect of deployment centralization on the distribution of teachers across schools within the county. $\alpha_3 < 0$ means that teacher-student ratios increase more among schools with low pre-reform teacher-student ratios in centralization *xiang*. That is, teacher input becomes more equitable in centralization *xiang*s than comparison *xiang*s. Vice versa.

Estimates are presented in Table 8. In terms of total-teacher-to-student ratio (column (1)), the average increase is smaller than centralization *xiang*s than in comparison *xiang*s. Moreover, in centralization *xiang*s, schools with greater pre- total-teacher-to-student ratio enjoy a greater increase in centralization *xiang*s than their counterparts in comparison *xiang*s. Contrary to the argument for equity-oriented centralization, it indicates that the allocation of teachers became less equitable in centralization *xiang*s.

The estimated result for the regular-teacher-to-student ratio (column (2)) exhibits the same pattern as that for the total-teacher-to-student ratio. Estimates are of the same magnitude. Though statistically insignificant, the effect on college-educated-teacher-to-student ratio are also consistent with these two measures. In terms of the allocation of contract teachers (column (3)), the pattern is a bit different. Although both the average effect and distributional effect are statistically insignificant, the estimated coefficients show that the number of contract teachers relative to students (column (4)) increased more in centralization *xiang*s. The increase is smaller in centralization *xiang*s among schools with greater pre- contract-teacher-to-student ratios. But the magnitude is

only 1/3 of the corresponding coefficient in regressions for total-teacher-to-student ratio, regular-teacher-to-student ratio and college-teacher-to-student ratio.

Recall that contract teachers are usually of lower qualification than regular teachers. The results consistently negate the hypothesis that centralizing deployment facilitates equitable allocation of teachers. On the contrary, there are signs that the allocation of regular teachers and college-educated teachers became even less equitable under centralized deployment. Therefore, the hypothesis that equalizing allocation of teachers hurts teachers' incentive is unfounded.

8.2 Centralization and incentive pay

An alternative channel is through the implementation of incentive pay. To examine this channel, we explore into regular teachers' wage structure to see whether the payoff in centralization *xiang*s become less merit-based. That is, we test that wages become less responsive to teachers quality measures (such as education diploma and working hours) and more responsive to seniority and job tenure in centralization *xiang*s.

The empirical specification is as follows.

$$\begin{aligned} ln(wages)_{istr} &= \alpha_1 T + \alpha_2 post + \alpha_3 T \times post + \beta_1 Q^j_{istr} + \beta_2 T \times Q^j_{istr} \\ &\quad + \beta_3 post \times Q^j_{istr} + \beta_4 T \times post \times Q^j_{istr} + X\gamma + \mu_{isrt} \end{aligned} \tag{12}$$

where Q^j_{istr} is the j-th characteristics of teacher i in school s in *xiang* r in time t; X is the matrix of control variables including school characteristics as well as the teacher's own characteristics. We construct four variables that measure different dimensions of teacher characteristics: teachers' education degree, weekly working hours, age and years of teaching.

The variables of interest is $T \times post \times Q^j_{istr}$. The coefficient of this variable captures how centralization changes the rate of return to certain characteristic of the teacher. If the pay becomes more merit-based in centralization *xiang*s, we expect that $\beta_4 > 0$ for teachers' education degree and weekly working hours; and $\beta_4 < 0$ for age and years of teaching. Vice versa.

Table 9 presents the results of regression (12) estimated for the four measures respectively. Dependent variables are listed on the top of each column. Concerned about the multicollinearity problem, we do not estimate the effects of all measures in one regression. Instead, we focus on one measure each time and cycle other measures in as control variables. Column (1) shows that the log wages associated with the educational attainment of the teacher.[25] Compared to the pre-reform rate of return, the wage increment for one level increase in educational degree is 6% lower in centralization *xiang*s than in comparison *xiang*s. That is, wages in centralization *xiang*s became less responsive to teachers' education degree.

The weekly working hours (column (2)) also exhibits a similar pattern though the effect is statistically insignificant and the magnitude is smaller. In contrast, column (3) and (4) show that wages in centralization *xiang*s became more responsive to the teacher' age and years of teaching. The results suggest that, the payoff becomes less merit-based and more seniority-based in centralization *xiang*s. Although not proved directly, it is likely that the implementation of performance pay is a channel through which deployment centralization hurts teachers' incentives.

It is worth emphasizing that from the main effects in the four regressions in table 9, we can see that the wage level has generally increased after the reform. Moreover, teachers in centralization *xiang*s have enjoyed a greater wage increase. The "county-oriented" reform has improved teachers' compensation. However, the flatter wage structure dampens teachers' incentive.

9 Conclusion

The policy changes examined in this paper is only the beginning of the new wave of fiscal centralization in China. Since then, the national government has been carrying out a series of reforms such as subsidizing rural students from national and provincial government, prohibiting schools from hiring contract teachers etc. All the measures

[25]The educational attainment is an ordered categorical variable: it equals 1 if the teacher's highest education degree is primary school; 2 if she gets a junior high school degree; 3 if she gets a senior high school degree; and 4 if he gets college degree or above. For simplicity, we use it as a linear variable here.

feature certain degree of fiscal centralization. These reforms aim to increase the input in rural education system. However, the productive efficiency of these reforms is rarely studied. School finance reforms are likely tipping the balance of power in the education system, and hence lead to changes in the allocation of personnel authority and other administrative power. Those changes are unlikely to be neutral. Evidence provided in this paper shows that centralization of teacher deployment could be undermining teachers' incentive and students' academic outcome. A likely channel is through weakening the link between teachers' pay and their performance.

While the evidence on the effectiveness of teachers' performance contract has been growing, little attention has been paid to the incentives of the implementer. The result in this paper points out the importance of the institutional setting to the implementation of incentive contract. Although China is somewhat exceptional compared to the rest of the world where fiscal decentralization has been fashionable, the centralization of teacher deployment is far from rare even in fiscally decentralized countries.

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To be added.

Appendices

A Gansu Survey of School Governance

We conducted a retrospective survey, the Gansu Survey of School Governance (GSSG), to collect information on school governance in 2006. This survey is supplementary to the Gansu Survey of Children and Families (GSCF), which contains detailed information on teachers and students. The GSSG covers the same pool of sampled schools as in the GSCF, including 180 rural primary and junior high schools in 50 *xiang*s of 20 counties in Gansu. Detailed Information was collected for year 2003 and 2005. Basic information on governance structure was collected for year 2000.

The questionnaires were designed for principals, teachers, local education officials and villagers (students' parents and randomly chosen villagers in the same community) respectively. Students' parents answered questions regarding communications with teachers, participation in school decision-making, family expenses on education, targeted educational attainment of children and so on. Specially we asked whether and how parents participate in mass movement in the past ten years to voice out concerns in the local education system.

Questions for the first three types of interviewees focus on school governance and policy changes. The interviews were individual-based and confidentiality was promised. Answers were cross-checked among different types of interviewees. We can extract important information on four groups of key educational decisions and responsibilities. Table 1 presents a summary.[26] The curriculum was set by and textbooks are selected by the national government. The reforms in 2001 does not change this nature. As we mentioned previously, centralization is mainly characterized by the locus of decisions on personnel and budgets. Centralization of personnel decision lagged that of budgets.

[26]Indicators used in the OECD countries.

Table 1: Key Educational Decisions and Responsibilities

Groups	Decisions	Pre-reform	Post-reform
Organization	Choose Textbooks	N	N
	Determine teaching methods	S/X	S/X
Personnel	Hire/fire school principals	X	C/X
	Recruit/fire/assign regular teachers	X/S	S/C
	Set or augment regular teacher pay	X	X
	Recruit/fire/assign contract teachers	S/X	S/X
	Set or augment contract teacher pay	S/X	S/X
	Set teachers' performance evaluation criterion	X	X
Planning	Set performance exams	C/X	C/X
Resources	Determine expenditures	X/S	N
	Allocate personnel budget	X	C/X
	Allocate non-personnel budget	X	C/X
	charge tuition	X/S	N

Table 2: The Evolution of Teachers' Assignment Power

	year 2004			
year 2000	town/school	county involved	county	total
town/school	28	6	8	42

Source: GSSG

Table 3: The Evolution of Principal Appointment Power

	year 2004				
year 2000	county govt	county educ bureau	town+educ bureau	town	total
county govt	1	0	0	0	1
county educ bureau	1	19	1	0	21
town+educ bureau	2	6	4	0	12
town	0	1	2	6	9
total	4	26	7	6	43

Source: the GSSG

Table 4: Summary statistics: Xiangs and Schools (pre-reform)

	comparison	centralization	Diff	bootstrap t
	(1)	(2)	(3)	(4)
***Xiang* Characteristics**				
Distance b/w 2 schools (km)	21.7	20	3.83	.685
	(12.5)	(11.5)	(4.07)	(1.08)
Mountainous road b/w 2 schools (km)	9	12.7	-3.06	-.878
	(14.1)	(13.2)	(4.45)	(1.08)
Distance from county govt. (km)	32.5	21.2	12.3*	1.79*
	(22.7)	(16.7)	(6.53)	(1.03)
Mountainous road from county govt (km)	7.71	6.11	2.34	.505
	(18)	(9.16)	(4.78)	(1.05)
N	21	18		
School characteristics				
pNpubteach	8.09	11.5	-3.44**	-.508
	(7.17)	(11.4)	(1.64)	(1.04)
pNinformte	2.46	2.47	-.0137	-.189
	(3.9)	(3.59)	(.688)	(1.11)
pNstud	243	293	-49.9	-.163
	(220)	(247)	(41.9)	(1.07)
pNclassroom	16.4	18.3	-1.83	.314
	(11.7)	(15.1)	(2.38)	(1.03)
N	79	49		

Table 5: Summary Statistics of Teachers

	Regular Teachers						Contract Teachers					
	pre-reform			post-reform			pre-reform			post-reform		
	Comp.	Central.	Diff	Comp.	Central.	Diff	Comp.	Central.	Diff	Comp.	Central.	Diff
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Male	.674	.674	-.000118	.565	.548	.0167	.478	.37	.108	.358	.333	.0252
			(.0376)			(.0413)			(.0852)			(.107)
Age	36.4	38.3	-1.87**	38	39	-1.03	28.8	29.4	-.64	29.9	34.1	-4.22
			(.852)			(.872)			(1.12)			(2)
Yrs. teaching	15.3	17.1	-1.87**	17.2	18	-.804	7.74	7.72	.0151	9.21	12.1	-2.85
			(.785)			(.847)			(1.01)			(1.74)
Yrs. this school	7.28	7.98	-.701	8.01	8.28	-.269	5.48	5.67	-.185	6.42	9.45	-3.04
			(.64)			(.642)			(.845)			(1.62)
Hr. teaching	13.5	13.2	.28	18.6	16.9	1.75**	13.8	15.5	-1.72	18.6	20.8	-2.15**
			(.384)			(.352)			(.855)			(1.08)
Education Diploma												
Primary	.209	.221	-.0123	.0194	.0294	-.0101	.217	.222	-.00483	.0566	.0606	-.004
			(.0329)			(.0127)			(.0714)			(.0525)
Junior	.509	.581	-.0725*	.568	.518	.0494	.609	.704	-.095	.679	.697	-.0177
			(.0399)			(.0414)			(.0823)			(.104)
High	.275	.186	.0888**	.394	.426	-.0329	.13	.0741	.0564	.264	.242	.0217
			(.0341)			(.0409)			(.0537)			(.0979)
College	.00763	.0116	-.00399	.0194	.0257	-.00638	.0435	0	.0435	0	0	0
			(.00767)			(.0123)			(.0279)			(0)
N												

Table 6: Regression Results: Teachers' Weekly Teaching and Grading Hours

	DD model		DDD model	
	Regular teachers	Contrac teachers	All teachers	All teachers
	(1)	(2)	(3)	(4)
T	3.638**	0.496	1.898	1.907
	(1.178)	(2.045)	(1.644)	(1.448)
Post	3.956**	3.116	1.426	0.927
	(1.148)	(2.496)	(2.020)	(2.211)
Being regular teacher			-1.551	-2.253
			(1.039)	(1.345)
T×Post	-2.479*	1.853	1.568	3.532
	(1.405)	(2.912)	(2.418)	(3.026)
T×$I(regularteacher)$			0.955	0.255
			(1.316)	(1.619)
Post×$I(regularteacher)$			2.872	3.874*
			(1.854)	(1.921)
T×Post×$I(regularteacher)$			-4.111*	-6.414**
			(2.337)	(2.657)
County dummies	yes	yes	yes	no
Rsquare	0.213	0.226	0.198	0.096
N	1390	325	1715	1715

Note: robust std. err. clustered at *xiang* level reported. ** $p < 0.05$; * $p < 0.1$.

Other controls include teachers' gender age, age square, years of teaching, years in this school; schools' student-teacher ratio, number of classrooms.

Table 7: Student Scores Improvement (Outcome variable: $\Delta score$)

	Boy		Girl	
	Chinese language	Math	Chinese language	Math
	(1)	(2)	(3)	(4)
Age2000	-0.009	0.013	0.004	0.081
	(0.082)	(0.098)	(0.098)	(0.099)
T	0.114	-0.297**	-0.034	0.041
	(0.118)	(0.149)	(0.154)	(0.145)
lagged score	-0.779***	-0.749***	-0.869***	-0.843***
	(0.077)	(0.092)	(0.077)	(0.076)
T × lagged score	-0.275**	-0.219	-0.174	-0.020
	(0.129)	(0.160)	(0.138)	(0.153)
Dad's yr. school.	0.044**	0.003	0.003	-0.013
	(0.016)	(0.017)	(0.022)	(0.018)
Mom's yr. school.	-0.030*	-0.001	0.015	0.033*
	(0.017)	(0.016)	(0.020)	(0.019)
R-square	0.436	0.380	0.467	0.438
N	293	247	217	225

Note: robust std. err. clustered at *xiang* level reported.

*** $p < 0.001$ ** $p < 0.05$; * $p < 0.1$.

Table 8: Changes in the Allocation of Teachers among Schools

	$Outcome\ variable: \Delta Y_s = Y_s - Y_{s,-1}$			
	$\Delta\frac{\#teacher}{\#student}$	$\Delta\frac{\#regular}{\#student}$	$\Delta\frac{\#contract}{\#student}$	$\Delta\frac{\#college}{\#student}$
	(1)	(2)	(3)	(4)
T	-0.021**	-0.019**	0.001	-0.001
	(0.009)	(0.007)	(0.003)	(0.004)
$Y_{s,-1}$	-1.164***	-1.152***	-0.833***	-0.443
	(0.198)	(0.298)	(0.156)	(0.314)
T$\times Y_{s,-1}$	0.518**	0.616**	-0.179	0.563
	(0.221)	(0.285)	(0.170)	(0.377)
County dummies	yes	yes	yes	yes
R-square	0.749	0.691	0.685	0.565
N	87	87	87	87

Note: robust std. err. clustered at *xiang* level reported.

*** $p < 0.001$ ** $p < 0.05$; * $p < 0.1$.

Other control variables include the number of students and its square, the number of classrooms, distance from the nearest schools, the distance from county government.

Table 9: Changes in the Wage Structure ($Outcome\ var : ln(monthly\ wage)$)

	Teachers' characteristics: Q_{itr}			
	Degree	Working Hours	Age	Years of Teaching
	(1)	(2)	(3)	(4)
T	-0.058	-0.093*	-0.080	-0.074*
	(0.051)	(0.049)	(0.066)	(0.040)
Post	0.402***	0.394***	0.330***	0.383***
	(0.036)	(0.047)	(0.035)	(0.025)
T×Post	0.212***	0.082	-0.076	0.014
	(0.056)	(0.095)	(0.073)	(0.044)
T×Q_{itr}	-0.002	0.002	0.001	0.001
	(0.026)	(0.002)	(0.001)	(0.002)
Post×Q_{itr}	0.017	0.000	0.003***	0.004***
	(0.012)	(0.002)	(0.001)	(0.001)
T×Post×Q_{itr}	-0.061**	-0.001	0.003*	0.003
	(0.023)	(0.003)	(0.002)	(0.002)
R-square	0.723	0.747	0.729	0.729
N	1206	1206	1206	1206

Note: robust std. err. clustered at *xiang* level reported.

*** $p < 0.001$ ** $p < 0.05$; * $p < 0.1$.

Other controls include teachers' gender square, years of teaching, years in this school; schools' student-teacher ratio, number of classrooms.