Women in Politics: A New Instrument for Studying the Impact of Education on Growth

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Abstract

This paper tests the growth model of distance to the technological frontier, which states that the closer an economy is to the frontier, the higher the relative importance of innovation relative to imitation as a source of productivity growth. Hence, an economy closer to the technological frontier should invest more in skilled labor since innovation is a skill-intensive activity. I use the proportion of female legislators as an instrument for skilled labor, in contrast to Vandenbussche, Aghion, and Meghir (2006) who used lagged educational expenditures. The results with the new instrument are consistent with the theoretical prediction and the previous results of Vandenbussche, Aghion, and Meghir (2006).

Keywords: distance to the technological frontier, women in politics.

JEL-codes: H52, I20, J16, O30, O40.

1 Introduction

Does education cause growth? One line of macro growth models treats the stock of human capital as a factor in improving technology, which in turn plays a role in the production function and contributes to growth. The assumption is that certain kinds of education equip a person to perform certain jobs or functions, or enable a person to perform a given function more effectively. Based on this assumption, Nelson and Phelps (1966) suggest that educated people make good innovators, so education speeds the forces of technological diffusion. Furthermore, if it is true that innovation produces externalities by showing the way to imitators, then this implies that education also yields externalities by its stimulation of innovation. This provides a way to view the effect of education on growth.

However, it is not effective for countries with different technological levels to take the same strategy for improving productivity. Acemoglu, Aghion, and Zilibotti (2006) claim that the closer an economy is to the world technological frontier, the higher the relative importance of innovation (relative to imitation) as a source of productivity growth because there is less room to copy and adopt well-established technologies. Their statement is based on the assumption that innovation is a relatively more skill-intensive activity

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than imitation. In other words, skilled labor has a higher growth-enhancing effect for countries closer to the technological frontier, and vice versa.

Vandenbussche, Aghion, and Meghir (henceforth VAM) (2006) examine the contribution of human capital to growth by combining distance to the frontier and human capital. They use a 5-year-interval dataset covering 19 OECD countries between 1960 and 2000, and deal with problems of endogeneity by using lagged public expenditures on education as an instrument for levels of human capital. Though the results are significant, their instrument may not be credible since it seems likely that expenditures on higher education 10 years ago may influence current growth rate through channels other than human capital. For example, increasing government expenditures on tertiary education may signify a government's aim to develop those industries with high R&D investment and thereafter raise private enterprises' incentives to make related domestic investments. Consequently, increasing domestic demand 10 years ago may impact current economic growth. Moreover, a high growth country will end up being rich, close to the technological frontier, and may spend more on tertiary education as a luxury good. In other words, countries with higher productivity growth may have both higher investment in tertiary education and continuous higher growth in productivity.

Aghion, Boustan, Hoxby, and Vandenbussche (2006) use U.S. data to find an exogenous source of variation in spending on education. This allows them to use a set of political factors as instruments for educational spending, where the instruments consist of the detailed composition of political committees. For example, their instruments for investments in research-university education are indicators for a state's number of legislators on federal appropriations committees, while the instruments for spending in primary and secondary school are the percentage of judges on the state's supreme court who are progressives and an indicator for whether the chief justice is a progressive. They find that Massachusetts, a close-to-frontier state in the late 1970s, did experience increased growth that coincided with its representative on the House Appropriations Committee generating an infusion of federal funding.

Building on the idea that political factors may influence educational investments, this paper re-examines the theoretical prediction of the growth model in VAM (2006) by using a new instrument. It has been suggested that education is one of the issues about which female politicians are concerned. There is also evidence of a positive effect of women's participation in politics on public educational expenditures from Chen (2008). It seems reasonable to expect that women support educational policies related to people's basic needs, such as increasing the schooling accessibility and literacy rate, at lower stages of economic development, [1] while it is more likely that women turn to support policies about improving quality of education after the infrastructure of compulsory education is well-established. Increasing the accessibility of higher education may be one of their secondary goals. This is not only to promote the development of knowledge, but also to address long-standing inequalities. [2] I, therefore, use the proportion of female

[1] See also Clots-Figueras (2007).

[2] Schwindt-Bayer (2007) points out that countries need to ensure that women are in the candidate pool by encouraging women to continue their education beyond secondary school. They should also be encouraged to pursue degrees in professional fields that can be springboards to a political career, such as a law degree. Another

legislators as an instrument for human capital.

In this paper, the analysis exploits the fact that women's political involvement may affect the fraction of people with higher education, primarily through their influence on budget process during their period in office. Thereafter, women's political involvement tends to have effects on 10-year growth, but may not, itself, be driven by future growth. It is not necessary, however, that countries with higher productivity growth have more female legislators. The proportion of female legislators seems to be a good instrument for assessing human capital. Nevertheless, there is trade-off between relevance and exogeneity for an instrument. While the share of female legislators provides an exogenous source for skilled labor, it may be less relevant in explaining the fraction of people with higher education.

The paper is organized as follows. Section 2 provides the theoretical framework of distance to the frontier in VAM (2006) and a discussion of the empirical model. Section 3 describes the motivation of using women in politics as a new instrument and investigates its correlation with education. Section 4 presents the results of the empirical analysis, where I replicate the results of VAM (2006) and compare those results with results obtained using female legislators as a new instrument. Section 5 concludes.

2 Theoretical and empirical framework

In this section, I first introduce the theoretical model of distance to the technological frontier in VAM (2006), and then present my empirical strategy.

Technological frontier models assume ability-biased technological change, and are natural frameworks by which to think about the importance of skill selection, especially as an economy comes closer to frontier. The technological improvement results from a combination of imitation and innovation. The former activities are aimed at adopting world frontier technology, while the latter activities are aimed at pushing forward the technological frontier. Both activities have unskilled and skilled labor as inputs. Following VAM (2006), technological progress is a linear function of imitation and innovation

$$A_{i,t} = A_{i,t-1} + \lambda[(\overline{A}_{t-1} - A_{t-1})u_{m,i,t}^{\sigma} s_{m,i,t}^{1-\sigma} + \gamma u_{n,i,t}^{\phi} s_{n,i,t}^{1-\phi} A_{t-1}] \quad (1)$$

where $A_{i,t}$ is the productivity in sector i at time t, $\overline{A}_{t-1}$ is the world productivity frontier at time $t-1$, A_{t-1} is the country's productivity frontier at the end of period $t-1$, $u_{m,i,t}$ ($s_{m,i,t}$) is the amount of unskilled (skilled) labor input used in imitation in sector i at time t and $u_{n,i,t}$ ($s_{n,i,t}$) is the amount of unskilled (skilled) labor input used in innovation in sector i at time t. The parameter σ (ϕ) is the elasticity of unskilled labor in imitation (innovation). $\gamma > 0$ measures the relative efficiency of innovation compared to imitation in generating productivity growth, and $\lambda > 0$ measures the efficiency of the overall process of technological improvement. Here it is assumed that $\phi < \sigma$, in order to reflect the higher intensity of skilled labor in innovation than in imitation. Equation (1) says that the productivity in sector i today is based

option for advancing the status of women is to get more women into the paid labor force and provide leadership training such that they can hold managerial positions.

on its productivity yesterday adjusted by the technological progress, where the progress results from both innovation and imitation activities. [3]

Final output y is produced competitively according to

$$y_t = l_t^{1-\alpha} \int_0^1 A_{i,t}^{1-\alpha} x_{i,t}^{\alpha} di$$

where $\alpha \in (0,1)$, $x_{i,t}$ is the flow of intermediate good i produced monopolistically and l_t is the amount of land used in final production at time t. VAM (2006) normalize the total supply of land to one. The local intermediate producer decides the output of $x_{i,t}$ by maximizing individual profits and this determines the demand for different types of labor at period t by maximizing the net post-innovation profit. Under the condition of labor-market clearing, the following equation is obtained

$$\frac{u_{m,t}}{s_{m,t}} = \varphi \frac{u_{n,t}}{s_{n,t}}$$

where $\varphi \equiv \frac{\sigma(1-\phi)}{\phi(1-\sigma)} > 1$. Therefore, $\frac{u_{m,t}}{s_{m,t}} > \frac{u_{n,t}}{s_{n,t}}$, which refers to the reallocation effect, (i.e., innovation employs skilled labor more intensively) while imitation employs unskilled labor more intensively.

In an economy endowed with an exogenous stock of U units of unskilled labor and S units of skilled labor, the growth rate of productivity is given by

$$g_A = \lambda\gamma\{Uh(a)^{1-\phi}\phi + Sh(a)^{-\phi}(1-\phi)\}$$

where $h(a)$ is a decreasing function of the proximity to the frontier, $a \equiv \frac{A_t}{\overline{A}_t}$. The effect of S on growth is increasing in a, while the effect of U on growth is decreasing in a. This indicates the composition effect. That is, if a country is closer to the frontier, it should invest more in skilled labor in order to enhance the economy. On the other hand, the innovation sector will expand since skilled labor tends to go to innovation relative to imitation, according to reallocation effect.

To summarize, the growth-enhancing effect of a marginal increase in the stock of skilled human capital is stronger the closer the economy is to the technological frontier. This the main theoretical prediction by VAM (2006) and is going to be re-examined in the following empirical analysis.

For the empirical model, I first assume that the stock of skilled human capital is the skilled fraction of the labor force. Following the methods of VAM (2006), the measure of skilled human capital stock is the fraction of people with more than a secondary school education. I estimate the following equation for labor productivity growth

$$g_{j,t} = \alpha_{1,j} + \alpha_2 a_{j,t-1} + \alpha_3 f_{j,t-1} + \alpha_4 a_{j,t-1} * f_{j,t-1} + \varepsilon_{j,t} \tag{2}$$

where $g_{j,t} = \log A_{j,t} - \log A_{j,t-1}$ is the labor productivity growth in country j at period t, $a_{j,t-1} = \log A_{j,t-1} - \log \overline{A}_{t-1}$ is the log of productivity in country j relative to the productivity frontier in the previous period and $f_{j,t-1}$ is the fraction of the population with higher education in the previous period.

[3] See Appendix for details on the derivation of the model.

$\alpha_{1,j}$ reflects country dummies. If the prediction from the model is correct, we will see a positive sign for α_3 for countries closer to the frontier, and a positive sign for α_4 as well. That is, given countries with similar distance to the frontier, those countries with more skilled labor will exhibit a higher growth rate.

Since there is a concern about the endogeneity of variables on the right hand side of equation (2), VAM (2006) estimate the distance to the frontier, $a_{j,t-1}$, by its lagged value, $a_{j,t-2}$. On the other hand, they use expenditures on tertiary education per capita lagged for two periods as an instrument for the fraction of the population with higher education, $f_{j,t-1}$. However, their instrument for human capital may not be credible for two reasons. First, it seems likely that expenditures on higher education 10 years ago influences current growth rate through channels other than human capital. Second, some countries with higher productivity growth may have both higher investment in tertiary education and continuous higher growth in productivity. Hence, I use the proportion of female legislators in parliament as an instrument for human capital. The next section discusses this new instrument.

3 New instrument for human capital: Women in politics

During the 1960s-1980s, the second wave of the feminist movement, political parties across Western Europe came under pressure to adopt policies attractive to female voters and to provide greater opportunities for women's participation in the formal political arena. This was the case even in those countries in which a well-organized women's movement was not developed. Women's perception of their role as representatives seems to differ from their male counterparts in some important ways.

Although women are just as likely as men to see themselves as delegates or trustees, women, in comparison to men, are more likely to see themselves as representatives of their gender. [4] They might be more inclined, therefore, to give priority to legislation about women, and they take pride in legislative accomplishments in traditional areas of concern to women. [5] Data collected by the Inter-Parliamentary Union (IPU) in 1992 highlight the fact that it is in the areas of family, social affairs, health, and education that women are most numerous in the parliamentary committee among countries in Western Europe, and these areas are those that are related to women's traditional role in the family. Though party discipline may restrict female legislators' work on women's issues, it appears that they are usually working across party lines to the extent permissible by party discipline. As women achieve a more sizeable presence, their policy impact may be even greater. Male legislators who work with a sizeable number of female legislators are more likely to sponsor legislation concerning the social, legal, and economic position of women than are male legislators in arenas in which women do not have a significant numeric presence. [6] The dynamics of

[4] Thomas (1994) points out that in the United States, female delegates have been found to value aspects of their jobs related to civic duty, while men have been more inclined to pay more attention to legislative effectiveness or status within the legislative chamber.

[5] This conclusion comes from a survey of both legislative houses in the U.S. by Thomas (1994). Davis (1997) studies the case among Western European countries and Wängnerud (2005) uses parliamentary survey studies conducted in the Swedish Parliament. Both groups obtained similar results.

[6] See Thomas (1994).

electoral competition may provide one interpretation. If male politicians do not sponsor more legislation concerning women, female politicians might take over the male legislators' vote shares from voters who care about women's needs.

Empirical studies, such as Lott and Kenny (1999) and Edlund and Pande (2002), discuss women's preferences about public policies. [7] There are also empirical studies analyzing female politicians' influence on policy outcomes, such as Besley and Case (2000), Pande (2003), Chattopadhyay and Duflo (2004), Clots-Figueras (2007), and Svaleryd (2007). [8] Overall, there is evidence that female politicians have systematically different preferences on public policies than male politicians, which is likely to affect the decision-making patterns and policy outcomes.

Chen (2008) provides evidence that in developed countries the greater the representation of women in parliament, the higher the educational expenditures, both as share of GDP and in per capita terms. [9] It seems reasonable to expect that women care about both the quantity and quality of children's education. Women support educational policies related to people's basic needs, such as increasing the schooling accessibility and literacy rates, at lower stages of economic development, while it is more likely that women turn to support policies regarding improving education quality after the infrastructure of compulsory education is well-established. Increasing the accessibility of higher education may be one of the initiative supported by female legislators. This support is not only aimed at increasing knowledge development, but also at addressing long-standing inequalities. In a developed country, the attention may focus on issues related to higher education more than on policies about primary and secondary education, and the representation of female legislators may play a role in determining this focus. In other words, women may tend to influence policies about higher education, which thereafter may impact the levels of human capital.

According to Edlund and Pande (2002), the rise of non-marriage in recent decades in Western society may result in different policy preferences between women and men since men were previously thought to transfer resources to women in marriage. Therefore, women may be encouraged to be self-supporting and enter the labor market with the increasing divorce rate, which, in turn, may raise their demand for gender equality in their career. Hence, women may favor those policies related to the improvement of

[7] Lott and Kenny (1999) show that women switched to preferring a big government after suffrage was granted to women; Edlund and Pande (2002) find that women are more likely to support Democratic party as divorce rate is getting higher.

[8] Besley and Case (2000) believe that women's traditional role in the family should make female legislators, relative to male legislators, care more about workers' compensation. The results strongly support that the fraction of women in upper and lower house is a highly significant determinant of the workers' compensation policy, which, in turn, reduces the unemployment rate and raise the average hourly earning of workers in construction sector. Pande (2003) finds that political reservation has increased transfers to groups which benefit from the mandate. Chattopadhyay and Duflo (2004) observe that Village Councils in India with woman as the leadership invest more in infrastructure, such as drinking water and roads, which are more closely linked to women's concerns. Clots-Figueras (2007) uses quasi-experimental election outcomes to estimate the causal effect of the gender of politicians, and finds that primary education attainment is higher in urban areas of India where female political representation is higher. Svaleryd (2007) studies whether the degree of women's representation in Swedish local councils affects local public expenditure patterns.

[9] There is also evidence from other empirical studies showing that women support educational spending once they are able to participate in politics. For examples, see Lott and Kenny (1999) and Svaleryd (2007).

women's social status, such as increasing women's opportunity to pursue higher education, once more women are able to participate in the decision-making process. Even in the case where expenditures on higher education are earmarked for women, those expenditures may create a gender-neutral climate for attending education beyond secondary school. In other words, in addition to women, men are likely to be influenced and pursue tertiary education as well.

Figure 1 presents the fraction of female legislators and the ratio of public expenditures on higher education to GDP in 19 OECD countries from 1960 to 2005. [10] The data is in 5-year intervals. The fraction of female legislators comes from *Women in Parliaments: 1945-1995. World Statistical Survey* issued by the IPU. [11] I only consider women's representation in the lower chamber. [12] It shows a positive correlation between the share of female legislators and educational investments for most of the countries.

I further pool all observations across countries and, in Figure 2, provide a simple graphical illustration of the relationship between the fraction of female legislators and expenditures on tertiary education per capita. While some caution is needed in interpreting this graph as nothing else is being controlled for, the figure shows that expenditures on tertiary education per capita is significantly and positively correlated with the fraction of female legislators.

VAM (2006) show that lagged expenditures on tertiary education is significantly and positively correlated to the fraction of people with higher education. [13] Accordingly, I expect that female legislators have an influence on the proportion of people with higher education through the budget process. There may be worry about endogeneity problems concerning women in politics. That is, countries with policies that are less discriminatory against women are be expected to have both a higher proportion of women in politics and more women with a higher education degree, which consequently raises the proportion of people with higher education. If this is the case, it is doubtful that higher levels of women in politics is the factor leading to an expansion of expenditures on education and an increase in the proportion of people with higher education. I, therefore, investigate whether there is correlation between the share of female legislators and the incidence of higher education in the combined male and the female population. The results are reported in Table 1, which shows that the proportion of female legislators is strongly correlated to both the incidence of higher education in the total population and also in the female population. Increasing female legislators by one percentage point increases the incidence of higher education in the total population and in the female population by 0.221 and 0.284 percentage points, respectively. Although the statistical power is not as high as that in the correlation between the proportion of female legislators

[10] These countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Greece, Ireland, Italy, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States, which are the same as those examined by VAM (2006).

[11] The series after 1995 is collected from the website of IPU.

[12] The results using the average fraction of female parliamentarians in the upper and lower houses are similar to the results using only the fraction of female parliamentarians in the lower house. Moreover, representation in the lower house is used in cross-national studies of this type because in bicameral systems lower house legislators generally have more legislative power than those in the upper house.

[13] This is reported in Table 2 in VAM (2006).

and the incidence of higher education in the total population and in the female population, there is a relevant correlation between the share of female legislators and the incidence of higher education in the male population. In other words, the greater share of women in politics not only reflects the increasing numbers of women with higher education degrees, but also benefits the educational status of the male population, both through female influence on budget allocation.

In short, the proportion of female legislators is positively correlated with the budget allocation to higher education during their period in office. Since the economic growth rate today is less likely to affect the representation of women in politics 10 years ago and it is not necessarily true that countries with higher productivity growth have more female legislators, the proportion of female legislators seems to be a good instrument for human capital. [14]

4 Empirical analysis

4.1 Data description

The dataset used here includes 19 OECD countries examined between 1960 and 2000, the same as is included by VAM (2006). These countries are well-developed countries and are supposedly specialize in innovation relative to imitation. [15] I use total factor productivity, obtained from VAM (2006), as a proxy for labor productivity growth. [16] Education data is taken from Barro and Lee (2001), who provide the distribution of the population across schooling attainment levels at 5-year intervals.

Since the period of observation, constrained by the availability of education data from Barro and Lee (2001), is every five years, there is quite a lot of persistence allowed. The right side variables are therefore treated as endogenous. The instrument for $a_{j,t-1}$ is the log of the proximity to the frontier lagged two periods ($a_{j,t-2}$), the same as VAM (2006). However, I take the proportion of female legislators lagged two periods as an instrument for $f_{j,t-1}$, while VAM (2006) use expenditures on tertiary education per capita lagged two periods as an instrument. Figure 3.3 presents the proportion of female legislators and the proportion of people with a higher education degree in each country from 1960 to 2000. Both the proportion of people with a higher education degree and the proportion of female legislators grow over time. Finally, the instrument for $a_{j,t-1} * f_{j,t-1}$ is the interaction of the two instruments. Descriptive statistics are provided in Table 2.

[14] For example, the U.S. is always at the technological frontier in this study, but the level of female legislators is relatively low across these 19 OECD countries. The regression results of the proportion of female legislators as the dependent variable and the productivity growth as the independent variable show that there is no correlation between these two variables. I include country and year dummies in the regression, and cluster at the country level.

[15] Note 13 in VAM (2006) state that "... our theoretical mechanism is less likely to be at play in low-income countries, which are specialized in imitation."

[16] In VAM (2006), total factor productivity is defined as output per adult minus capital per adult times the capital share, where capital stock is constructed by a classic perpetual inventory method assuming a depreciation rate of 6%. The results are not qualitatively affected using GDP per adult instead.

4.2 Replication of VAM (2006)

A replication of Table 3 from VAM (2006) is presented in Panel A of Table 3, which is also an estimation of equation (2) with the lagged educational expenditures as an instrument for assessing human capital. Columns (1) and (2) are the regressions without the interaction term. In column (1), country dummies are excluded, and there is a significant effect of proximity to the frontier on growth. In column (2), country dummies are controlled, and the result shows that human capital has a positive influence on growth. When the interaction term is included and country dummies are excluded, which is shown in column (3), there is a significant effect of human capital on growth given the distance to the frontier. However, this interaction effect disappears when country dummies are included. Therefore, VAM (2006) control for group dummies in column (5) instead. In general, the replication results are quite close to the ones in VAM (2006), which are copied in Panel B of Table 3. [17] In column (5), the interaction term shows that adults with tertiary education are more important for growth in economies closer to the frontier.

4.3 Results with women in politics as an instrument

Even though the instrument for the fraction of people with higher education in VAM (2006) seems to be relevant enough, it may not be credible. I therefore estimate the model by their specification but use the new instrument, the proportion of female legislators lagged two periods. Table 4 presents the reduced form for the models, i.e., the first stage in Two Stage Least Squares. All the regressions include country dummies and year dummies. The independent variables of interest are the log of the proximity to the frontier lagged two periods (i.e., 10 years before), the proportion of female legislators lagged two periods, and the interaction of these two instruments. The results are reported in Panel A. [18]

In column (1), lagged proximity explains proximity significantly. In the second reduced form for the proportion of people with higher education, lagged representation of female legislators has a positive relationship with the fraction of skilled adults when both country and year effects are included, though the relationship not significant. This effect is relevant, however, if group dummies and group specific trends are controlled. [19] In the third reduced form for the interaction of proximity with frontier and education, lagged proximity and lagged proportion of female legislators are positively correlated when they are interacted with each other. [20]

Table 5 provides the results for total factor productivity growth equation, i.e., estimation of equation (2). All the regressions control for country and year dummies at the first stage, and control for year

[17] The slight differences in estimates from those in VAM (2006) may be a result of different data sources of real GDP per capita, which is used to obtain the educational expenditures.

[18] Panel B in Table 4 presents the results using VAM's instrument, lagged expenditures on tertiary education, for skilled labor.

[19] Since the change of women's representation in politics is based on election year, its effect on human capital may disappear when the controls dummies for year are included. Moreover, country dummies may also take away the variation at the level of female legislators, and reduce the statistical efficiency of the estimate.

[20] The estimate of the interaction term is significant when I include all 130 observations. To drop observations for the purpose of providing comparable estimates with the results by using the instrument adopted in VAM (2006) may lead to a loss of information.

dummies at the second stage. Panel A reports the results with female legislators as an instrument for human capital, while Panel B reports the replication of Table 3 in VAM (2006). Column (1) of Panel A displays the regression without the interaction term and country dummies. The effect of lagged distance on growth is negative, which implies the convergence of labor productivity growth. Since the proximity is always negative except for the countries that are exactly on the frontier, the smaller the absolute value of proximity becomes, the closer the country is to the technological frontier. It therefore can be concluded that for a country far away from the frontier, the growth rate is stronger than for a country closer to the frontier. This may reflect the difficulty of innovation and the relative ease of imitation. Such an effect is not mediated by education.

When the interaction effect between proximity and the proportion of people with higher education is included and country dummies are excluded, which is the case in column (3), there is a positive and significant effect of education on growth. Skilled labor increases growth more in higher developed countries as compared to lower developed countries. Furthermore, the interaction effect is positive and statistically significant, which gives the same conclusion as VAM (2006) and is consistent with the prediction of the theoretical model. However, these effects vanish when the country dummies are included. This is also the case in the work by VAM (2006). Hence, those authors introduce group dummies by grouping countries according to geographical proximity and/or institutional proximity. [21] The results are displayed in column (5), and are encouraging in this respect. The new instrument for human capital, the proportion of female legislators, gives support to the theoretical model in addition to the instrument adopted in VAM (2006).

Even though the reduced form in Table 4 shows that lagged expenditures on tertiary education are more relevant than lagged representation of female legislators as an instrument for skilled labor, the new instruments may be more credible than the ones in VAM (2006). The increased credibility is conditional on the arguments that educational expenditures 10 years ago may influence current growth by its side effect on domestic investment, and countries with higher productivity growth may have both higher investment in tertiary education and continuous higher growth in productivity. This is less likely to be the case for the level of female legislators. Moreover, the results at the second stage with different instruments for skilled labor controlling for group dummies, i.e., column (5) in Table 5, are not different from each other very much.

However, there is concern about the relevance of the instrument from the results in the reduced form, where standard estimators can be severely biased and conventional methods for inference can be misleading. [22] Therefore I correct the size of standard errors using the method proposed by Moreira (2006). [23]

[21] This increases the efficiency of the estimates in VAM (2006).

[22] It has been argued that weak instruments do not cause a serious problem using the conventional methods such as Two Stage Least Squares (TSLS) and Limited Information Maximum Likelihood (LIML) in the just-identified case or lower degrees of over-identification. However, standard estimators can be severely biased and conventional methods for inference can be misleading when there is a high degree of over-identification. See Guido Imbens (2007). The model in this paper belongs to the category of high degree of over-identification because I always include country and year dummies at the first stage, while there are only three endogenous regressors.

[23] I take the predicted value of the reduced form of proximity to the frontier as an exogenous regressor when

Table 6 provides the results. In column (5), the estimate of the interaction term supports the theoretical prediction, i.e., given countries with similar distances to the frontier, those countries with more skilled labor will have a higher growth rate. [24]

To give further comparison of the validity of these two instruments, I instrument human capital by both the lagged level of female legislators and lagged expenditures on tertiary education. In column (5) of Table 7, the Hansen J statistic shows that both instruments are valid for assessing human capital, and the results continue to strongly support the growth model.

5 Conclusion

The purpose of this paper is to look for a new instrument for assessing human capital in the growth model. I adopt the proportion of female legislators as the best candidate because there may be significant differences in the legislative priorities between men and women. Their traditional role in the family makes women likely to give priority to legislation regarding issues about women, children, family, education, health, and welfare. Many studies have found that one critical factor in women's impact on policy is the size of their presence within the legislature, since they usually work across party lines, which is seldom observed with men occupying the same positions. Furthermore, the proportion of female legislators may influence the budget allocation to higher education during their period in office, which may be reflected in the increasing proportion of people with higher education degrees 5 years after and may generate an effect on economic growth another 5 years later. Since the economic growth rate today is less likely to affect the representation of women in politics 10 years ago, and it is not necessary that countries with higher productivity growth have more female legislators, the proportion of female legislators seems to be a good instrument for human capital.

I present evidence that the share of female legislators is positively correlated with tertiary educational expenditures, and VAM (2006) show that lagged educational expenditures is significantly and positively correlated to the fraction of people with higher education. I accordingly expect that female legislators have an influence on the proportion of people with higher education through the budget process. The estimate of the growth equation using the specification in VAM (2006) with the new instrument is consistent with the theoretical prediction after correcting for the size of standard errors. Moreover, the Hansen J statistic shows that both lagged educational expenditures and lagged representation of female legislators are valid instruments for human capital.

Basically, there are pros and cons for both instruments based on relevance and exogeneity. The reduced form shows that lagged representation of female legislators is less relevant to the fraction of skilled labor,

estimating equation (2) without the interaction term since Table 4 shows that the instrument is relevant. Then I estimate the growth model using the STATA command "condivreg". When estimating equation (2) with the interaction term, I take the predicted values of the reduced form of proximity to the frontier and the proportion of people with a higher education degree as exogenous regressors.

[24] The estimate of *Fraction* is significant when I include all 130 observations.

compared to lagged educational expenditures. However, the former instrument may provide a more credible source for human capital in the growth model since educational expenditures 10 years ago may influence current growth due to its side effects on domestic investment, and countries with higher productivity growth may have both a higher investment in tertiary education and continuously higher growth in productivity. This is less likely the case for the level of female legislators.

In general, this study offers a view of the effect of women in politics conditional on the growth model of distance to the technological frontier. It would be interesting to analyze the general effect of female legislators on growth *per se*. Moreover, female legislators may show their preferences on certain issues in tertiary education, such as increasing the opportunities for women to enter higher education rather than raising R&D expenditures, which may influence the productivity of certain types of labor. Therefore, using the representation of female legislators as an instrument for certain type of skilled human capital may lead to another avenue of research on productivity growth.

6 Appendix

Following VAM (2006), technological progress is a linear function of imitation and innovation:

$$A_{i,t} = A_{i,t-1} + \lambda[(\overline{A}_{t-1} - A_{t-1})u_{m,i,t}^{\sigma} s_{m,i,t}^{1-\sigma} + \gamma u_{n,i,t}^{\phi} s_{n,i,t}^{1-\phi} A_{t-1}]$$

where $A_{i,t}$ is the productivity in sector i at time t, $\overline{A}_{t-1}$ is the world productivity frontier at time $t-1$, A_{t-1} is the country's productivity frontier at the end of period $t-1$, $u_{m,i,t}$ ($s_{m,i,t}$) is the amount of unskilled (skilled) labor input used in imitation in sector i at time t and $u_{n,i,t}$ ($s_{n,i,t}$) is the amount of unskilled (skilled) labor input used in innovation in sector i at time t. The parameter σ (ϕ) is the elasticity of unskilled labor in imitation (innovation). $\gamma > 0$ measures the relative efficiency of innovation compared to imitation in generating productivity growth, and $\lambda > 0$ measures the efficiency of the overall process of technological improvement. Here it is assumed that $\phi < \sigma$, in order to reflect the higher intensity of skilled labor in innovation as compared to imitation. This equation says that the productivity in sector i today is based on its productivity yesterday, adjusted by technological progress, where the progress results from both innovation and imitation activities.

The final output y is produced competitively according to:

$$y_t = l_t^{1-\alpha} \int_0^1 A_{i,t}^{1-\alpha} x_{i,t}^{\alpha} di$$

where $\alpha \in (0,1)$, $x_{i,t}$ is the flow of intermediate good i produced monopolistically and l_t is the amount of land used in final production at time t. VAM normalize the total supply of land to one. The intermediate monopolist faces an aggregate inverse demand curve derived from the profit maximization problem on the final goods market

$$p_{i,t} = \alpha A_{i,t}^{1-\alpha} x_{i,t}^{\alpha-1}$$

where $p_{i,t}$ is the price of the intermediate good i. The local monopolist chooses $x_{i,t}$ to solve

$$\underset{\{x_{i,t}\}}{\text{Max}} \pi_{i,t} = (p_{i,t} - 1)x_{i,t}$$

which yields the equilibrium demand

$$x_{i,t} = \alpha^{\frac{2}{1-\alpha}} A_{i,t}$$

and total operation profit

$$\pi_F = \delta A_{i,t}$$

where $\delta \equiv (\frac{1}{\alpha} - 1)\alpha^{\frac{2}{1-\alpha}}$. All intermediate firms face the same maximization program, so that in equilibrium:

$$u_{m,i,t} \equiv u_{m,t}$$

$$u_{n,i,t} \equiv u_{n,t}$$

$$s_{m,i,t} \equiv s_{m,t}$$

$$s_{n,i,t} \equiv s_{n,t}$$

In an economy endowed with an exogenous stock of U units of unskilled labor and S units of skilled labor, the conditions for labor-market clearing in intermediate firms are defined as

$$U \equiv u_{m,t} + u_{n,t}$$

$$S \equiv s_{m,t} + s_{n,t}$$

The total labor cost of productivity improvement by intermediate firm i at time t can be written as follows

$$\underset{\{u_{m,t},u_{n,t},s_{m,t},s_{n,t}\}}{\text{Max}} \pi(t) - [w_{u,t}(u_{m,t} + u_{n,t}) - w_{s,t}(s_{m,t} + s_{n,t})]\,\overline{A}_{t-1}$$

where $w_{u,t}\overline{A}_{t-1}$ and $w_{s,t}\overline{A}_{t-1}$ are the wages of unskilled and skilled labor, respectively, and equal to the marginal productivity of labor in the final good sector. Assuming an interior solution, the first-order conditions of this maximization program can be written as

$$\begin{aligned} w_{u,t}\overline{A}_{t-1} &= \lambda\delta(\overline{A}_{t-1} - A_{t-1})\sigma u_{m,t}^{\sigma-1} s_{m,t}^{1-\sigma} \\ &= \lambda\delta A_{t-1}\gamma\phi u_{n,t}^{\phi-1} s_{n,t}^{1-\phi} \end{aligned}$$

$$\begin{aligned} w_{s,t}\overline{A}_{t-1} &= \lambda\delta(\overline{A}_{t-1} - A_{t-1})(1-\sigma) u_{m,t}^{\sigma} s_{m,t}^{-\sigma} \\ &= \lambda\delta A_{t-1}\gamma(1-\phi) u_{n,t}^{\phi} s_{n,t}^{-\phi} \end{aligned}$$

Dividing across equations, we obtain

$$\frac{u_{m,t}}{s_{m,t}} = \varphi\frac{u_{n,t}}{s_{n,t}}$$

where $\varphi \equiv \frac{\sigma(1-\phi)}{\phi(1-\sigma)} > 1$. Therefore, $\frac{u_{m,t}}{s_{m,t}} > \frac{u_{n,t}}{s_{n,t}}$, which is referred to as the reallocation effect (i.e. innovation employs skilled labor more intensively while imitation employs unskilled labor more intensively).

Moreover, the growth rate of productivity is given by

$$g_A = \lambda\gamma\{Uh(a)^{1-\phi}\phi + Sh(a)^{-\phi}(1-\phi)\}$$

where

$$h(a) \equiv [\frac{(1-a)(1-\sigma)}{\gamma a(1-\phi)}\varphi^{\sigma}]^{\frac{1}{\sigma-\phi}}$$

is a decreasing function of the proximity to the frontier, $a \equiv \frac{A_t}{\overline{A}_t}$, since

$$h^{'}(a) = \frac{1}{\sigma-\phi}[\frac{(1-a)(1-\sigma)}{\gamma a(1-\phi)}\varphi^{\sigma}]^{\frac{1-\sigma+\phi}{\sigma-\phi}}\varphi^{\sigma}[\frac{1-\sigma}{\gamma(1-\phi)}][-\frac{1}{a^2}] < 0$$

In addition, the effect of S on growth is increasing in a, while the effect of U on growth is decreasing in a.

$$\frac{\partial^2 g_A}{\partial S\partial a} = \lambda\gamma(1-\phi)(-\phi)h(a)^{-\phi-1}h^{'}(a) > 0$$

$$\frac{\partial^2 g_A}{\partial U\partial a} = \lambda\gamma(1-\phi)\phi h(a)^{-\phi}h^{'}(a) < 0$$

This indicates the composition effect. That is, if a country is closer to the frontier, it should invest more in skilled labor in order to enhance the economy. In this paradigm, the innovation sector will expand since skilled labor drives innovation rather than imitation, according to the reallocation effect.

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Table 1: Correlation between the share of female legislators and the fraction of higher education in certain population

Dependent Variable	Total Pop.	Male Pop.	Female Pop.
	(1)	(2)	(3)
Share of female legislators	.221	.151	.284
	(.075)***	(.087)*	(.084)***
R^2	0.98	0.97	0.97
Observations	132	132	132

Note: 1. Standard errors in parentheses. One, two and three * indicate significance at the 10, 5 and 1% level respectively. 2. Standard errors are corrected for clustering at the country level. 3. All of the regressions include group dummies and group trends. 4. The sample period is from 1970 to 2000 at 5-year intervals.

Table 2: Descriptive statistics

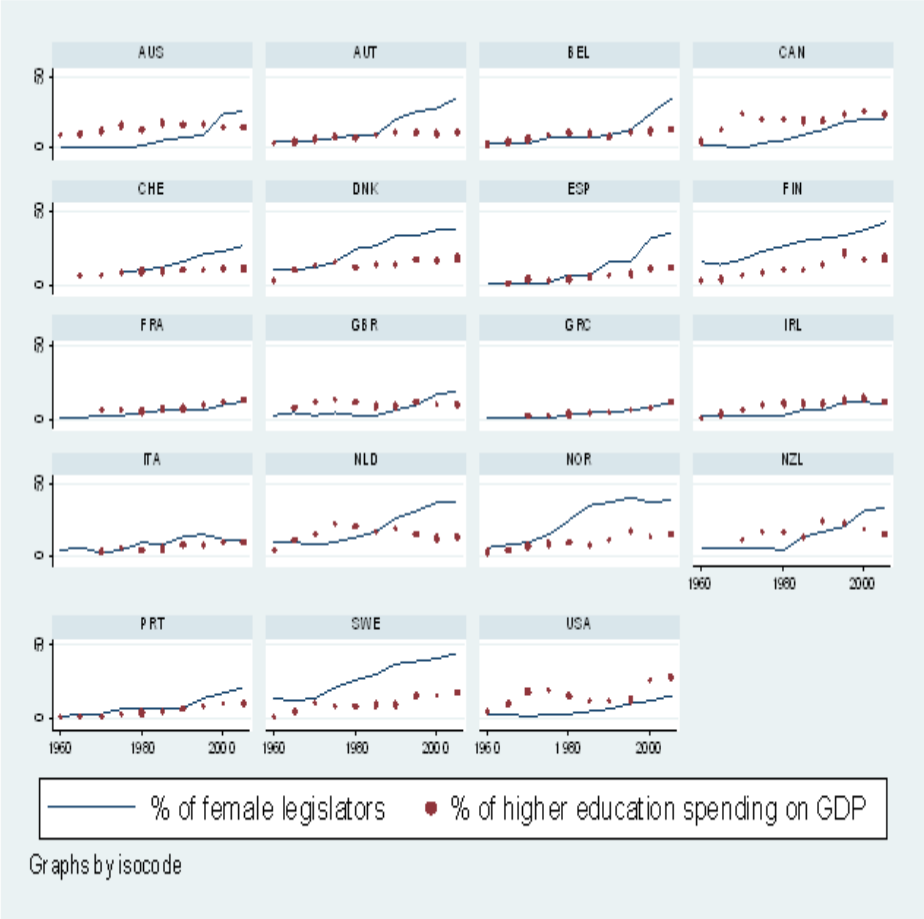
	Means	S.D.	Min	Max
Proximity				
TFP	-0.31	0.15	-0.68	0
Education				
% of people with higher education	13.40	10.72	1	54.30
Instrument of education				
% of female legislators in lower house	13.46	11.58	0	45.27

Table 3: Replication of VAM (2006)

Panel A: replication of Table 3 in VAM (2006)					
	(1)	(2)	(3)	(4)	(5)
Proximity	-.077	-.230	-.158	-.251	-.329
	(.045)*	(.144)	(.041)***	(.139)*	(.049)***
Fraction	-.036	.381	.125	.481	.340
	(.079)	(.437)	(.048)***	(.388)	(.113)***
Prox*frac	-	-	.755	.599	1.314
			(.193)***	(.877)	(.303)***
Country dummies	No	Yes	No	Yes	Groups
Weak IV F statistics	23.277	4.979	18.373	3.084	6.431
(Critical value)	(4.39)	-	(4.28)	-	(4.37)
Observations	122	122	122	122	122
Panel B: copy of Table 3 in VAM (2006)					
	(1)	(2)	(3)	(4)	(5)
Proximity	-.079	-.230	-.157	-.240	-.320
	(.050)	(.170)	(.044)***	(.170)	(.055)***
Fraction	-.032	.410	.123	.470	.331
	(.084)	(.490)	(.051)**	(.440)	(.120)**
Prox*frac	-	-	.740	.420	1.270
			(.210)***	(.960)	(.340)***
Country dummies	No	Yes	No	Yes	Groups
Observations	122	122	122	122	122

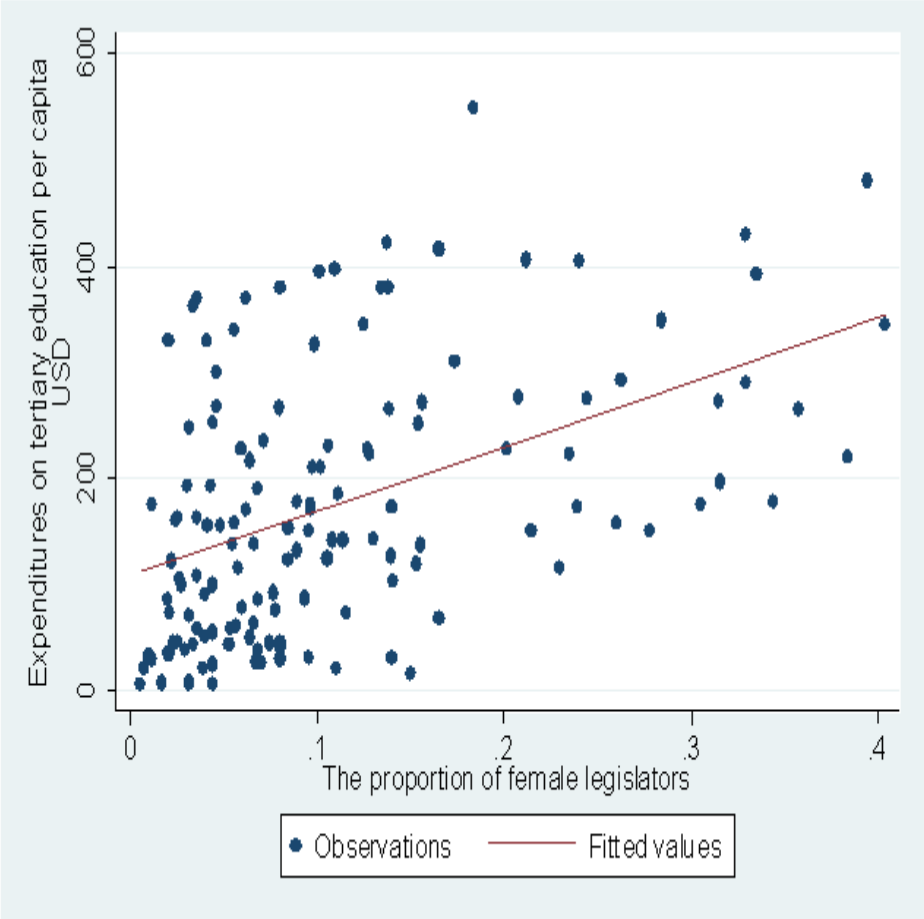
Note: 1. Standard errors in parentheses. One, two and three * indicate significance at the 10, 5 and 1% level respectively. 2. Standard errors are corrected for clustering at the country level. 3. Weak IV F statistics denotes Cragg-Donald F test, which is used for weak identification test. Critical value is Stock-Yogo weak ID test critical value at 30% maximal IV relative bias. 4. All of the regressions at the first stage include country and year dummies.

Figure 1: Female legislators and expenditures on tertiary education



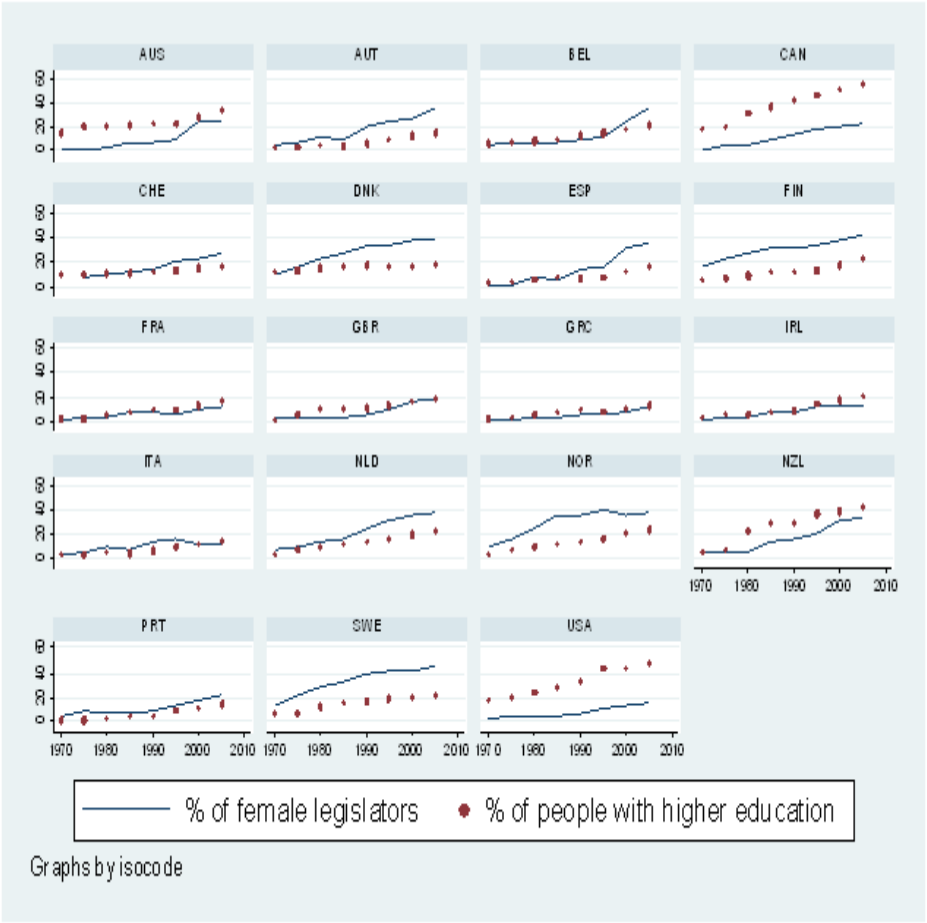
Note: 1. x-axis is year, and y-axis is percentage. 2. In order to study the pattern these two variables, I scale up the ratio of higher educational expenditures to GDP by 10 times. 3. Country isocodes are "AUS" for Australia, "AUT" for Austria, "BEL" for Belgium, "CAN" for Canada, "DNK" for Denmark, "FIN" for Finland, "FRA" for France, "GRC" for Greece, "IRL" for Ireland, "ITA" for Italy, "NLD" for Netherlands, "NZL" for New Zealand, "NOR" for Norway, "PRT" for Portugal, "ESP" for Spain, "SWE" for Sweden, "CHE" for Switzerland, "GBR" for United Kingdom, and "USA" for United States.

Figure 2: Correlation between female legislators and expenditures on tertiary education per capita



Note: x-axis is percentage.

Figure 3: Female legislators and people with higher education



Note: x-axis is year, and y-axis is percentage.

Table 4: Reduced form

Panel A: female legislators as an instrument for skilled labor			
	Proximity	Fraction	Prox*Frac
	(1)	(2)	(3)
Lagged proximity	.670	-.126	.033
	(.091)***	(.118)	(.031)
Lagged fem	-.529	.320	.015
	(.285)*	(.277)	(.071)
Lagged prox*fem	-2.152	1.446	.134
	(1.084)*	(.991)	(.251)
R^2	0.99	0.98	0.95
Observations	120	120	120
Panel B: educational expenditures as an instrument for skilled labor			
	Proximity	Fraction	Prox*Frac
	(1)	(2)	(3)
Lagged proximity	.594	-.054	.006
	(.111)***	(.088)	(.030)
Lagged exp	-.000	.000	.000
	(.000)***	(.000)**	(.000)
Lagged prox*exp	-.001	.001	.000
	(.000)**	(.000)	(.000)***
R^2	0.99	0.98	0.95
Observations	120	120	120

Note: 1. Standard errors in parentheses. One, two and three * indicate significance at the 10, 5 and 1% level respectively. 2. Standard errors are corrected for clustering at the country level. 3. The results in Panel B is comparable with Table 2 in VAM (2006) if tertiary expenditures are in thousand dollars.

Table 5: Total factor productivity growth equation

Panel A: the results with the new instrument					
	(1)	(2)	(3)	(4)	(5)
Proximity	-.057	-.213	-.136	.016	-.334
	(.042)	(.457)	(.036)***	(2.062)	(.054)***
Fraction	-.063	.382	.090	1.185	.409
	(.071)	(2.414)	(.042)**	(5.837)	(.163)**
Prox*frac	-	-	.676	-1.959	1.482
			(.168)***	(22.907)	(.357)***
Country dummies	No	Yes	No	Yes	Groups
Weak IV F statistic	18.883	0.200	12.090	0.016	3.441
(Critical value)	(4.39)	-	(4.28)	-	(4.37)
Observations	120	120	120	120	120
Panel B: replication of Table 3 in VAM (2006)					
	(1)	(2)	(3)	(4)	(5)
Proximity	-.065	-.197	-.144	-.211	-.313
	(.042)	(.183)	(.036)***	(.187)	(.047)***
Fraction	-.049	.500	.106	.567	.345
	(.073)	(.551)	(.040)***	(.488)	(.111)***
Prox*frac	-	-	.712	.398	1.285
			(.183)***	(.969)	(.305)***
Country dummies	No	Yes	No	Yes	Groups
Weak IV F statistic	22.237	3.319	18.113	2.168	6.670
(Critical value)	(4.39)	-	(4.28)	-	(4.37)
Observations	120	120	120	120	120

Note: 1. Standard errors in parentheses. One, two and three * indicate significance at the 10, 5 and 1% level respectively. 2. Standard errors are corrected for clustering at the country level. 3. Weak IV F statistics denotes Cragg-Donald F test, which is used for weak identification test. Critical value is Stock-Yogo weak ID test critical value at 30% maximal IV relative bias. 4. All of the regressions at the first stage include country and year dummies.

Table 6: Total factor productivity growth equation with correct size of s.e.

	(1)	(2)	(3)	(4)	(5)
Proximity	-.057	-.213	-.136	.016	-.334
	(.042)	(.416)	(.057)**	(1.430)	(.099)***
Fraction	-.063	.382	.090	1.185	.409
	(.072)	(2.711)	(.104)	(3.761)	(.295)
Prox*frac	-	-	.676	-1.959	1.482
			(.365)*	(14.943)	(.669)**
Country dummies	No	Yes	No	Yes	Groups
p-value	0.336†	0.888†	0.016‡	0.900‡	0.018‡
Observations	120	120	120	120	120

Note: 1. Standard errors in parentheses. One, two and three * indicate significance at the 10, 5 and 1% level respectively. 2. All of the regressions at the first stage include country and year dummies. 3. † refers to conditional p-value for the estimate of *Fraction* estimated by LIML. ‡ refers to conditional p-value for the estimate of *Prox*frac* estimated by LIML.

Table 7: Comparison of instruments for human capital

	(1)	(2)	(3)	(4)	(5)
Proximity	-.065	-.198	-.146	-.213	-.315
	(.042)	(.205)	(.041)***	(.216)	(.057)***
Fraction	-.047	.490	.110	.565	.353
	(.071)	(.543)	(.062)*	(.534)	(.160)**
Prox*frac	-	-	.718	.384	1.295
			(.335)**	(.941)	(.386)***
Country dummies	No	Yes	No	Yes	Groups
Hansan J statistic	17.479	0.002	18.205	0.036	4.034
Chi-sq p-value	0.558	0.965	0.574	0.982	0.995
Observations	120	120	120	120	120

Note: 1. Standard errors in parentheses. One, two and three * indicate significance at the 10, 5 and 1% level respectively. 2. Standard errors are robust. 3. The Hansen J test is a test of overidentifying restrictions. The joint null hypothesis is that the instruments are valid instruments. 4. All of the regressions at the first stage include country and year dummies.