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The Economics Department and Omicron Delta Epsilon congratulate Brian Lemak, winner of the *2010 Dwight D. Eisenhower Society / R.M. Hoffman Family Memorial Prize in Economics*. The Eisenhower/Hoffman Prize is awarded to the economics student writing the best quantitative paper or project with public policy implications. Brian's paper, "*An Examination of Non-linear Relationships between Intellectual Property Rights Protection and Growth*," is the lead article in this issue of the Gettysburg Economic Review.

The Economics Department and Omicron Delta Epsilon congratulate **Kristina Marinova**, winner of the 2010 John Edgar Baublitz Pi Lambda Sigma Award.

The Economics Department and Omicron Delta Epsilon congratulate **Denitsa Koleva**, winner of the 2010 Financial Executives International Award.

The Economics Department and Omicron Delta Epsilon congratulates **Tim Kurpis**, winner of the 2010 Wall Street Journal Award.

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**Economics Graduation Banner Carrier:
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**2010 Best Honors Thesis Award:
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An Examination of Non-Linear Relationships between Intellectual Property Rights Protection and Growth

Brian Lemak

Abstract

This paper examines the possibility of a non-linear relationship existing between intellectual property rights protection (IPR) and gross domestic product (GDP) growth rates. A theoretical justification is developed for the potential existence of a non-linear relationship in terms of a quadratic relationship. This is then examined using panel data from 191 countries and taken in 5 year intervals, although the data had many missing observations. Results indicate there is statistically significant evidence that a quadratic relationship exists between IPR and GDP growth, however there are reservations about this evidence due to a dearth of observations in countries with very weak intellectual property rights protections.

I. Introduction

The Solow growth model indicates that growth depends on three factors: capital, labor and technology growth. Capital and labor are rather simple to define and measure. The difficulty in properly generating a Solow growth model lies in modeling technological change. Other results in the literature, namely Lai (1998), have shown that using foreign direct investment (FDI) and intellectual property rights protection (IPR) can serve as good proxy variables for technology growth. However, these results do not consider potential non-linear relationships between IPR and growth.

Taking inspiration from Helpman's (1993) North-South model of trade, I propose a new model for looking at long run growth. Helpman argues that there is an innovating country in the North and an imitating country in the South

and develops a model of trade around this premise. The Northern country could also be a firm that has some form of technology and the Southern country could be a firm which imitates technology, although not necessarily domestic technology. Applying the model this way, changes in IPR policy will be seen in GDP growth, with policies where the benefit to the innovating firm outweighs the cost to the imitating firms will lead to increases in GDP growth. Policies where the costs to the imitating firms outweigh the benefits to the innovating firm will see GDP growth fall, thus giving two different responses in the growth rate for the same policy change. As a result, the direct impact of IPR on growth would have a non-linear impact, quadratic in this case. This will be discussed in more detail later in the paper.

If this non-linearity truly exists then there are major policy implications internationally. Simply increasing IPR will not necessarily lead to more growth. The IPR must be

calibrated to be in balance with the needs of the innovating and imitating firms. This method of calibrating IPR based on domestic market structure will be more efficient than the current IPR regimes only if this non-linear relationship exists. This paper will seek to determine if this non-linear relationship exists.

In the next section the relevant literature will be reviewed and their importance to this study will be discussed. The third section will outline the theoretical model I will use to determine if this non-linear relationship exists. The fourth section will discuss the empirical model that will be used based on conclusions the theoretical model gives. The fifth section will be devoted to the interpretation of results. The sixth section will examine statistical critiques of the model and ensure that the results are statistically justified which will be followed by the final section where I

will discuss my conclusions and indicate any avenues for future research.

II. Literature Review

The article, “International Trade, Economic Growth and Intellectual Property Rights: A Panel Data Study of Developed and Developing Countries,” by Patricia Higinio Schneider (2005) investigates an empirical specification that investigates a relationship closely related to my work. Schneider’s purpose for the study was based on the idea that countries may experience different technological diffusion based on whether or not they are a developed or a developing country. If these different diffusion rates exist and have a large enough impact, it could imply that different types of countries require different policy regimes to encourage growth.

Unlike the other papers in the literature, Schneider uses a much larger set of developing nations in her data.

Including these countries should allow for more meaningful results, as small sample sizes of developing nations could have lead to bias in earlier work. Schneider uses aggregate data at the country level, instead of the usual micro-level models in the literature. While this specification loses some detail, it allows Schneider the ability to make more inferences for countries and country groupings. Her results indicate that separating developed and developing countries yields different results than specifications which include both groups together, however I believe that simply correcting for country-specific omitted variables by using a fixed effects approach will suffice for my model.

The most shocking result was in regard to the impact of IPR protection in the split specification using innovation as the dependent variable. As expected, the coefficient on IPR protection was positive and significant in the developed countries model. The results for the developing countries

model showed a negative relationship, and in some specifications this was a significant result. This result would seem to confirm Schneider's hypothesis that there are different diffusion rates for developed and developing economies, since the impact of IPR protection is so radically different. If the diffusion rates were the same, the coefficient on IPR would be fairly close together. Since Schneider's results have a significant difference between developed and developing countries, it makes it likely the diffusion rates are different.

The GDP specification showed little of the divergence seen in the innovation specification. IPR is only significant in the regression that includes all countries, and only when fixed effects are applied, indicating there may be country-specific omitted variables that need to be corrected. This does confirm the findings of Gould and Gruben (1996);

however it seems to contradict the findings in the innovation specification.

Schnedier's conclusions about the divergent results on the coefficient of IPR are that the innovation that occurs in developing nations may be more directly related to other technologies than what occurs in developed nations. If this is true, then increasing IPR protections would stifle innovation in developing nations, and provide an adversarial relationship between firms in developed versus developing economies. This is similar to the reasoning I have used in my North-South adaptation which will be discussed in greater detail in the next section.

The article "Intellectual Property Rights and Economic Growth," by Rod Falvey, Neil Foster and David Greenaway (2006) investigates the impact of IPR on economic growth in a panel data using 79 countries and threshold regression techniques. Their results indicate that

the relationship between IPR and growth depends on the initial level of GDP in a non-linear fashion. They make special note that in no case did increased IPR protection lead to negative growth, so there are no real changes for policy recommendations. They found that there is no impact for middle income countries but high and low income countries experience positive effects from increasing IPR. The authors theorize this may be due to middle income countries being more likely to engage in imitation. However, this makes little sense to me since it is even more likely that low income countries would engage in imitation, since middle income countries would be engaging in imitation because they can gain net utility from the imitation of outside innovation. It stands to reason that low income countries could get the similar utility from imitation, but the results indicate this is not true.

The authors argue that simply squaring IPR or creating an interaction term between IPR and initial GDP is not sufficient. They base this argument off of results obtained, indicating that the coefficient estimates on these variables were not significant. However, this conclusion was based on results from a smaller dataset than I plan on using. The threshold model works quite well, however I think the authors may have been able to find success with the much simpler specification.

The article “Patent Rights and Innovative Activity: evidence from national and firm-level data,” by Brent B. Allred and Walter G. Park (2007) investigates the impact of IPR on innovation. The authors find that significant non-linear relationships exist, however care must be taken in applying these results to this paper. This paper dealt with the impact of IPR on innovation and while innovation clearly has an impact on GDP, there is no guarantee that IPR will

display the same non-linear relationships when growth is the dependent variable instead of innovation.

There is a theoretical reason to believe the relationship should carry through. According to the authors patent filings are dependent on IPR and IPR squared in addition to other variables. Suppose, instead of foreign direct investment (FDI) and IPR, these proxies for technology growth were replaced with patent filings. Then the model will still have IPR in it and because IPR are in the equation in both linear and non-linear form, the model would also have IPR in linear and non-linear form after substitution. Thus, the model specification with both IPR and IPR squared is theoretically justified from the results of Allred and Park, since they showed the existence of non-linear relationships when innovation is used as the dependent variable.

The article “International Intellectual Property Rights Protection and the Rate of Product Innovation,” by Edwin L.-C. Lai (1998) investigates the impact of FDI and IPR on a country’s innovation rate in a theoretical manner. Lai’s results lead to a number of theorems which are quite relevant to this research mainly that stronger IPR will lead to lower innovation and a lower wage rate of the South relative to the North, provided that imitation is the main source of innovation for the South. If this is not the case and so-called “multinationalization” is the main source of growth, stronger IPR will lead to higher innovation and a higher wage rate of the South relative to the North. This is the theoretical reason this “multinationalization” concept must be accounted for, which will be included in the model via the FDI variable. This gives the ability to control for countries where imitation is the main source of growth and for countries where multinationalization is the source of growth.

III. Theoretical Methodology

Before developing the empirical model for this paper, stronger justification at the theoretical level is needed.

Consider a country with two types of firms, innovating firms which create their own intellectual property and imitating firms which do not create their own intellectual property, but use intellectual property developed by others either domestically or internationally. This is similar to the model of trade developed by Helpman (1993), however in this case the trade is applied to the domestic economy and there is some distribution of innovating and imitating firms at the domestic level. Now, suppose that the government decides to increase IPR, holding everything else constant. Firms are now faced with a decision to innovate or imitate. The increase in IPR makes it easier for innovating firms to recoup innovation investment costs, thus making more innovation activity viable. The innovating firms will choose

to innovate and the imitating firms will choose to imitate the technology that comes from innovating firms. The innovating firms' innovation will lead to new technologies emerging and as imitating firms adopt those technologies productivity increases and as a result GDP growth increases.

However, with stronger IPR in place, it is more likely that the imitating firms can be taken to civil court for an intellectual property violation. As a result, the diffusion of technology to other firms will slow out of concern about lawsuits and/or fighting any IP infringement lawsuits. The legal profession is one where no generally applicable innovation occurs. New legal arguments and new laws can come from the legal area, but legal firms getting more revenue and higher profits will not lead to the same productivity growth as technological diffusion does. If IPR increases continue, the likelihood of an imitating firm being taken to court for IP violations will approach 1. As a result,

the diffusion of new technology will slow even further, preventing any growth in productivity and thus allowing GDP growth to stagnate.

However, if no IPR exist there will be no incentive for innovating firms to innovate since they will have no ability to make up the research costs. As a result, no technology can be created to diffuse to the imitating firms and GDP growth will stagnate. This setup indicates that there must be some point between no IPR and “infinite” IPR where the GDP growth rate is maximized. An actual prediction for this maximization point would require information about firms’ decision strategies, a true measure of lawsuit likelihood and other variables that are not available empirically. However, this model would indicate that the relationship between IPR and GDP growth is not entirely linear. The simplest non-linear model would be a model where GDP growth was impacted by IPR in a

negative quadratic fashion. This would give some maximization point between no IPR and “infinite” IPR and also allow for stagnant growth at very extreme values of IPR. As a result, an empirical model which showed the existence of a negative quadratic relationship between GDP growth and IPR would be evidence supporting the validity of this theoretical model. Additional ways of testing this could be by looking at patent rate or the allocation of resources between production, innovation and bureaucracy. These are somewhat more complex than looking at GDP growth rates, but should also show some sort of non-linear relationship with IPR. The remainder of this paper will focus on an investigation of the GDP growth rate empirical model.

IV. Empirical Methodology

The model for this paper will help determine if a significant non-linearity exists in the relationship between GDP growth and IPR. Evidence that would help to prove

this would be regression results which show a coefficient estimate that is statistically significant in difference from 0. I hypothesize this coefficient will be negative due to the theoretical ramifications of a negative coefficient. Namely, it would imply that there can be deleterious effects from having an IPR regime that is too strict. Contradicting evidence would be a coefficient that is not statistically significant in difference from 0.

A properly specified model is needed to test this hypothesis. Clearly, GDP growth will be the dependent variable and IPR squared will be an independent variable. Neither of these variables have any units associated with them, since IPR is an index and GDP growth will be measured by the natural log of GDP, which lacks any units. Beyond that relevant theory must drive model construction. The first variable to add is IPR. IPR squared is already included, but to ensure the full effect of IPR is included, IPR

should be included. Based on Lai (1998), a term that can account for multinationalization is needed. Foreign direct investment (FDI) will account for this potential relationship; however the natural log of this variable will be used due to FDI being measured in dollars, since the dependent variable is a unit-less variable.

The remainder of the model will stem directly from the traditional Solow growth model. An assumption that labor force participation is constant over the long-run is sensible here, so there is no need to include any variables related to employment. However, human and physical capital stocks are not static. To account for changes in capital I will use the fact that capital divided by GDP will be proportional to the investment rate in the long-run. Thus, the ratio of investment spending to total GDP as our measure of the investment rate will be used. The benefit of this measurement is it has already removed units from

consideration, so there is no need for any further modifications to the variable. This still leaves human capital stock unaccounted for so a measure of educational achievement will be included to control for human capital effects. Specifically some measurement of enrollment rates or a comparable statistic will be used. This again will not have any units, so no further transformation is needed. Finally, the current level of real GDP per capita will be used to control for any differences in growth due to convergence effects. The model is thus:

$$\text{pcgrowth}_{it} = \beta_0 + \beta_1(\text{investratio}_{it}) + \beta_2(\text{enroll}_{it}) + \beta_3(\text{Ln}(\text{FDI}_{it})) + \beta_4(\text{IPR}_{it}) + \beta_5(\text{IPR}^2_{it}) + \beta_6(\text{Ln}(\text{rGDP}_{it}))$$

However, it is possible that the impact of IPR on growth is not immediately felt. As a result, a second specification will be run with values of IPR and IPR^2 lagged one period. I expect the coefficients on all variables but IPR^2 and $\text{Ln}(\text{rGDP})$ to be positive in both specifications. I expect a

negative coefficient on IPR^2 because it would be consistent with the non-linearity that I outlined in the previous section. The negative expected coefficient on $\ln(rGDP)$ comes from the fact that the Solow model predicts that wealthier countries will grow slower than poorer countries, everything else being equal.

V. Data

Ideally data for this study would be a yearly measure of all the above variables from every country starting at around 1960 and progressing to the present day with no missing observations. Unfortunately, this type of data is not available. Thus, data from every 5 years will be used due to the only reliable dataset for IPR (the Park-Ginarte dataset) only having 5 year increments available. Additionally, there is no data for enrollment rates that dates back far enough for the purposes of this study. Primary school completion rates from the World Development Index will be used as a proxy

for enrollment as this data does go back for a few decades. Unfortunately, there are a large number of missing observations due to countries not reporting. Since this is the only viable measure of human capital for this type of study, there are no options other than using this data while being wary of potential issues. Specifically, only around 600 observations for primary school completion exist while the measurement of IPR and other variables have over a thousand observations, although these datasets are also incomplete.

There is still another problem with the data. The 2005 values for IPR were collected by the International Property Rights Index with help from one of the authors of the Park-Ginarte dataset. Unfortunately, this data was an index from 0 to 10 while the previous values were an index from 0 to 5. I corrected this by dividing all the 2005 values by 2, but this difference in measurement could result in some

measurement error. More importantly, the IPR data is an index which has dubious statistical qualities. This could induce some level of measurement error, but similar to the issue with human capital data there is no viable alternative. The values for percent growth rate, investment ratio and initial real GDP all come from the Penn World Tables version 6.3. The values for FDI and primary school completion rate come from the World Bank Human Development Indicators. All the values for IPR, except for the 2005 values which were discussed earlier, come from the Park-Ginarte dataset. The dataset covers a total of 191 countries. Table 1 provides further details on the general statistics of the variables in the model.

Table 1 Summary Statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
pcgrowth	1426	7.165795	7.625921	-18.00167	106.717
investratio	1614	.2100859	.130203	.0116	1.0492
ln(fdi)	681	74.80013	28.03788	3.976747	138.1592
completion	1026	18.35626	2.934997	9.21034	26.49556
ipr	1109	2.484707	.8748409	0	5
ipr ²	1109	6.938425	4.282599	0	25
ln(rgdp)	1614	7.794784	1.355245	4.511518	11.19713

These missing observations could play a large role in the ability to determine the validity of the hypothesis. By having so many missing observations, the sample size is drastically decreased. This increases the likelihood of a non-representative sample and will also inflate the standard errors. As a result of this, vigilance is needed when observing standard errors. The issue of potential measurement error in IPR is a more distressing problem, as this will bias our estimates and change our standard errors. Fortunately, the errors related to the 2005 sample can be removed by simply removing the 2005 sample. This is not

the best solution, however if the errors prove to be large enough to bias results it is a remedy available.

VI. Results

Table 2 Regression output

	Standard fixed effects model results (t-statistics)	Lagged fixed effects model results (t-statistics)
Investratio	35.9561*** (5.73)	37.99499*** (6.55)
Completion	-.071811** (-2.17)	-.0578015* (-1.80)
Ln(fdi)	.6962578*** (3.16)	.5503132** (2.49)
IPR	2.145613 (0.97)	
IPR2	-.9584257** (-2.19)	
Ln(rgdp)	-3.162094*** (-3.76)	-3.431289*** (-3.85)
constant	19.39636 (3.47)	21.86361 (3.34)
Lag(IPR)		1.106924 (0.41)
Lag(IPR ²)		-.4786142 (-0.92)
Observations	430	421
R ²	.2966	.2775
Prob>F	0.000	0.001

* statistically significant in difference from 0 at the .1 level

** statistically significant in difference from 0 at the .05 level

*** statistically significant in difference from 0 at the .01 level

For the standard fixed effects model, the coefficient estimate on investment ratio indicates that a change of .1 in the investment ratio will increase the growth rate of GDP by 3.595 percentage points, holding constant the influence of the other included variables. The p-value associated with this estimate (0.000) indicates that one rejects the null hypothesis that the coefficient estimate is 0. This coefficient estimate is statistically significant in difference from 0.

The coefficient estimate on primary school completion rate indicates that a change of 1 will decrease growth by .072 percentage points, holding constant the influence of the other included variables. The p-value associated with this estimate (0.031) indicates that one rejects the null hypothesis that the coefficient estimate is 0. This coefficient estimate is statistically significant in difference from 0.

The coefficient estimate on $\ln(\text{FDI})$ indicates that a change of 1 in the natural log of FDI will increase growth by .696 percentage points, holding constant the impact of the other included variables. The p-value associated with this estimate (0.002) indicates that one rejects the null hypothesis that the coefficient estimate is 0. This coefficient estimate is statistically significant in difference from 0.

The coefficient estimate on IPR indicates that a 1 point change in IPR will increase GDP growth by 2.146 percentage points, holding constant the impact of the other included variables. The p-value associated with this estimate (0.334) indicates that one fails to reject the null hypothesis that the coefficient estimate is 0. This coefficient estimate is not statistically significant in difference from 0.

The coefficient estimate on IPR^2 indicates that a 1 point change in IPR will decrease growth by .958 percentage points, holding constant the impact of the other included

variables. The p-value associated with this estimate (0.029) indicates that one rejects the null hypothesis that the coefficient estimate is 0. This coefficient estimate is statistically significant in difference from 0.

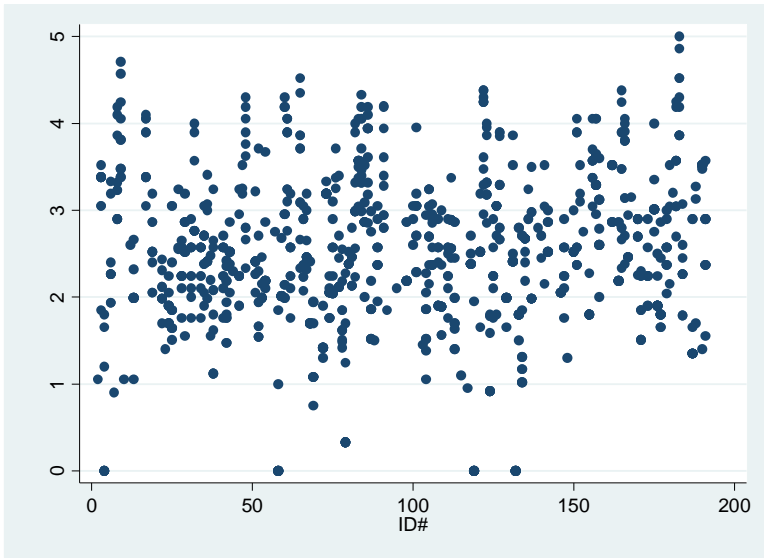
The model's R^2 value indicates that approximately 30% of the variation in the growth rate of GDP can be explained by the variation in the independent variables. The Prob>F value (0.000) indicates that one rejects the null hypothesis that the coefficients on all included variables is 0.

Generally speaking, the results for the standard model were in line with expectations. With the exception of completion rate all coefficient estimates had proper signage. However, the negative coefficient on completion rate does have an economic explanation. The coefficient estimate on $\ln(rGDP)$ was negative and statistically significant in difference from 0. This would indicate that wealthier countries grow slower, everything else in the model being

held constant. However, wealthier countries are more likely to have a high rate of primary school completion. Thus, the negative statistically significant in difference from 0 coefficient estimate is due to the wealthier countries growing slower and having a higher primary school completion rate.

These results do indicate there is a statistically significant in difference from 0 squared relationship between IPR and growth rate. This gives some weight to the argument that there is a non-linear relationship between IPR and growth rate, but caution must be exercised. Figure 1 indicates that very few countries have extremely weak intellectual property rights regimes. As a result, any inference about the impact of IPR on growth rates when IPR is less than 1 must be taken with a grain of salt. It is for this reason that caution is needed when discussing the existence of non-linear relationships between IPR and growth.

Figure 1 IPR vs. ID



Neither of the IPR variables in the lagged model was statistically significant in difference from 0 at the .1, .05 or .01 confidence levels. This would indicate that, despite some theoretical backing, past values of IPR do not have an impact on growth rates today. This is a rather curious result and warrants further investigation.

VII. Empirical Model Critique

Table 3 Correlation Coefficients

	investratio	completion	lnfdi	ipr	ipr2	lnrgdp
investratio	1.0000					
completion	0.5307	1.0000				
lnfdi	0.3147	0.5853	1.0000			
ipr	0.2132	0.3089	0.3512	1.0000		
ipr2	0.2420	0.3214	0.4099	0.9662	1.0000	
lnrgdp	0.5236	0.7729	0.7276	0.4590	0.5044	1.0000

There is little theoretical reason to believe any of these variables, save IPR IPR², and ln(rGDP) should exhibit any multicollinearity. A correlation study, seen in Table 3, indicated there was no significant correlation between any of the independent variables except those noted earlier, confirming this belief. The multicollinearity associated with ln(rGDP) is somewhat worrying, however the standard errors were low enough and the inclusion of ln(rGDP) important enough that correcting for the multicollinearity will hurt the

theoretical strength of the model. As a result, no action was taken to correct for multicollinearity. The standard errors are very close to normally distributed as seen in Figure 1.

Additionally, there appears to be no evidence of any serious serial autocorrelation or heteroskedasticity as seen in Figures 2 and 3 respectively. As a result, no correction was made due to the relatively small impact these statistical problems could have on the model.

Figure 2 Histogram of Errors

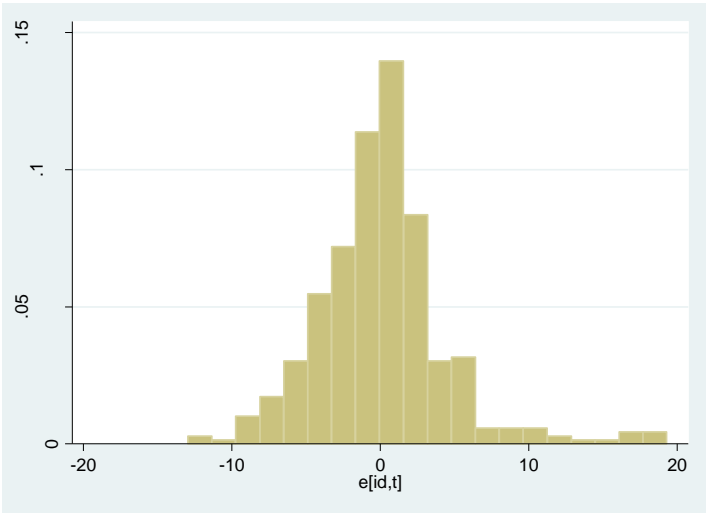


Figure 3 Errors vs. Year

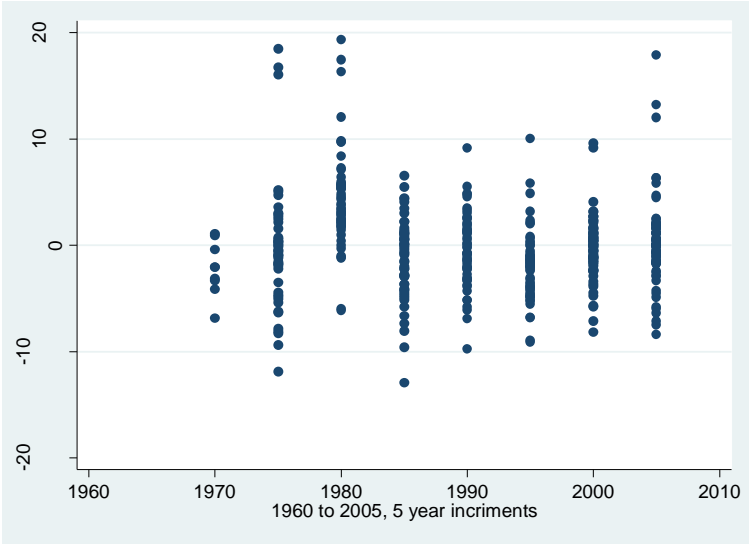
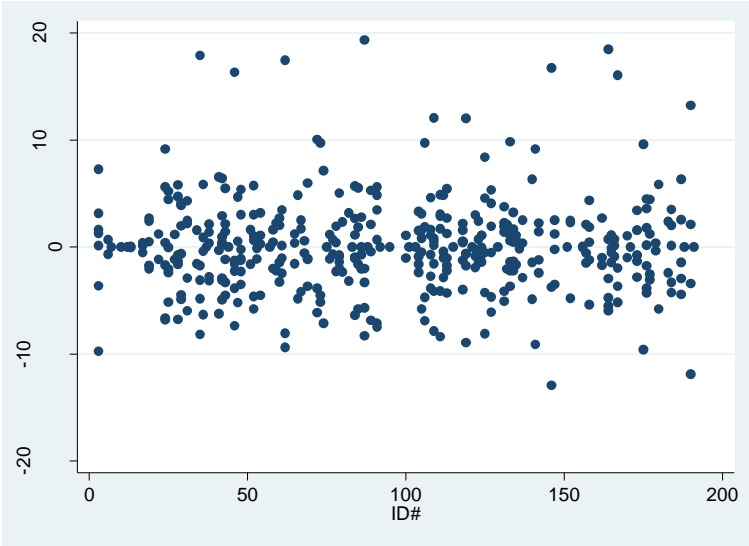


Figure 4 Errors vs. Country ID



The question of the model having possible measurement error is a valid one, considering that countries may have outright lied or “massaged” numbers when surveyed by the publishers of this data. However, if there is any measurement error which truly biases the model it would have to exist over multiple decades (and multiple government regimes) and multiple countries. This is fairly unlikely simply because of the mathematical implications of basic probability theory. If one assumes that one country has a 50% chance to lie during data collection in one period, the combined probability of even ten of the observations being lies is quite low (less than .1%). Additionally, even if a large set of countries did lie, they would also probably have lied in other surveys, making any kind of correction by using a proxy variable rather difficult. As a result, though measurement error could exist, this model will not account

for it because of the low likelihood it exists and the difficulty of correction if it does exist.

Endogeneity was considered as another possible issue but at the theoretical level it does not make much sense. If endogeneity did exist it would say that growth rate dictates IPR policy, but because growth rate is highly variable, with a standard deviation of 7.63 and a mean of 7.17 (see table 1), policy makers would be constantly adjusting IPR. As a result IPR would also be highly varied. It is not possible to say how exactly the relationship worked, but if growth rates have high variability and determine IPR, then IPR should also have a fairly high variability. This does not fit with the basic summary statistics for IPR as IPR has a standard deviation of .87 and a mean of 2.48. If growth rates were truly determining IPR, IPR should be highly varied like growth rates are, with a standard deviation fairly close to the mean. But there is a much larger gap between the mean of

IPR and the standard deviation of IPR then is seen with growth rate, which would confirm this theoretical argument for endogeneity not being an issue.

VIII. Conclusion

To conduct this study I used panel data from a number of sources and a model that included IPR, IPR^2 , $\ln(FDI)$, investment ratio, $\ln(rGDP)$ and primary school completion rate. There was some concern about potential measurement errors in IPR due to IPR being an index from 0 to 5; however there was no real solution as the dataset in this paper is the best dataset available for measuring IPR.

Additional concerns were raised about missing observations in both IPR and primary school completion rate. Primary school completion rate was used because no enrollment rate variables had the necessary time scale that was needed for this study. Similar to the concerns about measurement error

in IPR, there was no real solution to the concerns about missing observations in the variables as no alternative was available.

The results did show statistically significant in difference from 0 evidence of a quadratic relationship between IPR and GDP growth. Care must be taken in interpreting this as evidence of a non-linearity existing because of a dearth of observations where IPR was less than 1. Other results confirming this relationship would allow for more confidence in stating a non-linear relationship between IPR and GDP growth exists. Additionally, there was a statistically significant in difference from 0 negative coefficient on completion rate. This makes theoretical sense, despite contradicting a priori expectations, since wealthier countries are more likely to grow slower and more likely to have a high completion rate.

Future studies should attempt to replicate these results and determine if these results are valid. Results which can confirm this relationship would make arguments for the existence of non-linearities much stronger. Additional studies may also want to look at alternate specifications since the lagged specification did not show any statistically significant from 0 relationship between IPR and growth despite having a fairly strong theoretical basis. Future work may also want to investigate the other empirical ways of proving IPR works on the economy in a non-linear fashion which were mentioned in the theoretical methodology section. Specifically, the impact IPR will have on patent rates or the impact IPR will have on distribution of resources between production, innovation and bureaucracy.

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Globalization and Economic Growth in Sub-Saharan Africa

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Abstract

This study analyzes Sub-Saharan Africa through the framework of globalization. The study's objective is to determine whether globalization is a significant factor when associated with economic growth in the region. Using panel data from 1995-2005 for 41 countries and the KOF globalization index, an Ordinary Least Squares (OLS) model was employed to examine the relationship between globalization and other traditional factors of economic growth such as trade, foreign direct investment, loans, aid, natural resources, corruption, and rule of law. The study shows that globalization has a positive, though statistically insignificant impact on the economic growth of Sub-Saharan Africa. However, globalization is positive and statistically significant for countries with scarce natural resources. I interpret these results as proving that the leading causes of slow economic growth in Sub-Saharan African countries is due to heavy dependence on natural resources, low investment in human capital, and the negligence of other industries—all of which suggest that these countries are unable to effectively manage critical processes of globalization. Indeed, in order to reap the net benefits of globalization, I argue, African countries need to work towards economic stability by developing better macroeconomic policies for their future.

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Introduction

In this new era of international interdependency and interaction called globalization, there has been much controversy over the benefits of globalization to developing countries, especially to African nations. The issue of globalization is especially important considering the history of sub-Saharan Africa. With the exception of Liberia and Ethiopia, most of the region has been colonized at some point in its history. During the mid-twentieth century, for example, both the International Monetary Fund (IMF) and the World Bank imposed neoclassical economic policies, such as Structural Adjustment Programs (SAPs), on Sub-Saharan Africa in the hopes of opening up and integrating it into the global market (Schneider, 2003; Ajayi, 2003; Dreher, 2006). Neoclassical economic policies are associated with pro-market liberalization of trade, capital

control and labor markets, reductions of all kinds of state regulation, and privatization of state-owned enterprises.

There are many findings that suggest these SAPs were more harmful to these nations than beneficial. But other scholars have concluded that SAPs did not have such a detrimental effect. Meagher (2003) articulated this point in her analysis of globalization and trade in West Africa, stating that “instead of disappearing into the face of structural adjustment and globalization, West Africa’s trans-border trade systems have been restructured and globalized.” Yet, where the presence of globalization has not always been in the best interest of the local communities, the paradox is that African leaders themselves welcome the opportunity to promote globalization (Otenyo, 2004). Where SAPs did not benefit African nations, they did stimulate trans-border trade by enforcing the global policy framework of deregulation

and privatization of government enterprises and by helping to improve trade in communication and technologies.

This paper studies the aggregate impact of globalization on the economic growth of Sub-Saharan Africa, using the traditional neoclassical growth model, with panel data from 1995 to 2005 and for 41 African countries.² The decade 1995 to 2005 is important because African nations had enough time to recover from SAPs and pursue policies that could enable them to embrace the process of globalization.

I utilized the Ordinary Least Square (OLS) estimation to analyze this panel data, controlling for countries' characteristics by including dummy variables. Previous studies of globalization and economic growths used proxy variables such as trade, which by itself is not of the best variable, to determine how globalized a particular economy

² I wanted to use data for all of Sub-Sahara Africa, but due to the lack of data for the variables employed in this paper, I was limited to 41 countries.

might be. I used the KOF globalization index to measure globalization. The KOF index measures nations' overall integration into the global economy. According to the KOF index of globalization, globalization is defined as the process of creating networks of connections among actors at multi-continental distances, mediated through a variety of flows, including people, information and ideas, and capital and goods, while eroding national boundaries, integrating national economies, cultures, technologies and governance. Along with other traditional measures of economic growth that are often utilized in other studies—these range from foreign aid to foreign direct investment (FDI), investment in human capital, trade, and corruption, just to name a few—this study used the OLS method to determine whether globalization impacts economic growth in Africa. Following this method, I measured whether globalization is a significant and positive factor to the economic growth of

African nations. Furthermore, I attempt to explain how African nations can benefit economically from globalization in ways similar to other regions of the world such as Asia and the Middle East, which are growing economically at a faster rate than Africa.

The contribution of this study to globalization literature is that it underlines the reality that globalization is not a statistically significant contributor to the economic growth of countries with abundant natural resources. It also highlights the fact that, on the other hand, globalization is significantly important for small countries, especially those countries with “scarce” natural resources. Indeed, when managed systematically in the proper context, globalization can have a positive and significant contribution to economic growth of Sub-Saharan Africa. For one, nations that are highly globalized tended to be less corrupt than less globalized ones. And nations that are less corrupt tend to

have high economic growth. The empirical findings from this study underscore that globalization has a positive contribution to economic growth of Sub-Saharan Africa generally, but that its contribution is not statistically significant.

The rest of this paper is organized as follow. Section I provides literature reviews. Section II provides the methods used to conduct this study: an empirical OLS estimate regression model on globalization. Section III presents the estimation results of the simple multiple regression models. Section IV provides discussion and interpretation of these results. Section V draws conclusions and makes some policy recommendations about how to improve globalization in order to benefit Africa, and explores areas for further research.

I. Literature review

Researchers have long been interested in determining the factors of economic growth in Sub-Saharan Africa and how globalization affects growth. Some scholars have argued that the overall effect of globalization is positive for developing countries whether by trans-border or international integration (Meagher, 2003; Otenyo, 2004; Schneider, 2003). The ratio of extra-regional trade to GDP in Africa is twice that of Latin America and nearly four times that of Europe (Schenider, 2003). The global community is pushing toward a rapid and sustainable development, thus pressing African nations even more toward openness and globalization. Due to this push, African nations are relatively open and globalized. Schneider (2003) argued that globalization is not a new phenomenon in Africa: Africa began to be integrated into the global economy in the sixteenth century, and this integration has continued,

although unevenly, since that time. Furthermore, African countries are also linked directly to their former colonial powers, who often are their largest trading partners.

On the contrary, other scholars maintain that African nations do not have the potential to effectively integrate into the global economy. A major concern is that while other emerging market economies have benefited from globalization, African countries continue to be marginalized (Oshikoya, 2008). Meagher (2003) concluded in her study that globalization, for example, tended to stimulate rather than eliminate illegal and counterproductive activities across Africa. She points out that, as a direct result of unstable and short-sighted political and macroeconomic policies, Africa is mismanaging globalization rather than capitalizing on the net benefit of globalization. In addition, Africa does not have an adequate political and economic infrastructure to effectively manage globalization, therefore reinforcing its global

position as economically disadvantaged. These scholars would probably agree that globalization is taking advantage of Africa and that it is not a reciprocal relationship in terms of the benefit gained from globalization.

The benefits of globalization can accrue to Africa if governments take advantages of the following channels of globalization: trade, capital flows, migration, communication, and technologies (Ajayi, 2003). Indeed, if managed correctly, the benefit to Africa of globalization can be significant. Africa can diversify its exports, so that instead of exporting only minerals or primary commodities, globalization would allow it to generate exports developed through new or less active industries. For example, with improved communication and technology, Africa can expand its manufacturing industries thereby attracting foreign capital, which in turn can bring in new ideas and new technology (Ajayi, 2003). Against the backdrop of increased

trade and investment, economic growth is the only way to develop because it can reduce a country's level of poverty and increase the standard of living. Of course, the benefit derived by each African nation will be different because of different characteristics such as the level of education, the available natural resources, infrastructural development, and political stability, all of which can be greatly improved by globalization.

African governments want to benefit from globalization in the sense that they too advocate for globalization. The desire to embrace the potential benefits of interconnectedness remains strong in most governments of the developing world (Otenyo, 2004). Indeed, many economists agree that the route to the global economy remains straightforward, most pointedly, as noted above, through trade and investments. Yet Africa's entry into the global markets is complicated by its poverty, debts, and great

dependence on natural resources. Necessary steps must be taken in order for Africa to benefit from globalization. African governments are involved in managing natural resources instead of globalization. According to Otenyo (2004), data shows that since 1996, following the emergence of rapid globalization, East African city governments has become increasingly positive, leading to the conclusion that globalization can even positively reform how nations govern themselves. This and other studies shed light on the concrete benefits of globalization in Sub-Saharan Africa.

II. Method—an empirical model of economic growth

This study uses panel data for 41 Sub-Saharan African countries covering the period 1995 to 2005 on globalization and other traditional factors of economic growth. A total of 11 independent variables are used in this study. The model used in this paper is the classical regression model, the Ordinary Least Square (OLS)

Regression, under the Gaus-Markov assumptions. The model is specified as:

$$\begin{aligned} \text{Log GDP} = & \beta_0 + \beta_1 \text{aid} + \beta_2 \text{loans} + \beta_3 \text{FDI} + \beta_4 \text{export} + \\ & \beta_5 \text{import} + \beta_6 \text{rulelaw} + \beta_7 \text{humancap} + \\ & \beta_8 \text{naturalresources} + \beta_9 \text{Global index} + \beta_{10} \text{LagGDP} + \\ & \beta_{11} \text{Corrupt} + \epsilon \end{aligned}$$

(1)

The model passed the Ramsey test which tests for omitted variable bias (p-value 0.61). I also ran a Variance Inflation Factors (Vif) to identify the problem of multicollinearity. The test shows that we do not have the problem of multicollinearity, meaning that the independent variables are not correlated with one another since the mean vif is 2.58; all the variables have a vif less than 10. Also, I tested for heteroskedasticity to ensure that the standard errors of the estimates are not biased. The standard errors must be constant. Homoskedasticity implies that the conditional on

the explanatory variables, i.e. the variance of the unobserved error, ϵ , was constant. Using the Pagan test, I failed to reject the null hypothesis (p-value 0.0596). Therefore, there is no problem of heteroskedasticity.

The dependent variable used to capture economic growth is log Gross Domestic Product (GDP). GDP is the most important variable in studying economic growth. The log GDP is taken for simplicity of description and interpretation of results. The independent variables used in the model are described as follows.

“Aid per capita,” measured by both official development assistance and official aid, is used to capture the impact of an external source of capital on economic growth. Scholars who advocate for aid argue that foreign capital flows are necessary for the economic growth of developing countries (Fayissa and Nsiah, 2008).

“Loans per capita” are measured in terms of IBRD loans and IDA credit extended by the World Bank Group to developing countries. Loans are also used to capture their effect on economic growth. Many studies find that loans are negatively correlated with economic growth in Sub-Saharan Africa, adversely affecting the economic growth.

“Foreign Direct Investment” (FDI) measured as a percentage of GDP, is the net inflow of foreign enterprise operating in an economy other than that of the investor. FDI is used here to capture the effect of the outside source of capital on economic growth of developing nations. There are controversies over the benefit of foreign direct investment in Africa.

“Export” and “Import”. The term of trade measured as export plus import divided by GDP. Trade is another variable that determines how open an economy is to the global market. In this model, I separated export from import

to determine their impact separately on economic growth.

Ajayi (2003) mentioned that trade liberalization has been shown to be associated with increased export orientation and higher rate. However, this has not been the case for Africa; rather, most African nations have seen an increase in import instead of export.

“Rule of law” and “corruption” measured the accountability of government officials. The promotion of the rule of law throughout Africa is lacking. African nations are among the lowest ranking on the rule of law index. The Corruption Perceptions Index (CPI) measures the perceived level of public-sector corruption taken from Transparency International.

“Net enrollment/attendance rates in primary school” are used as a proxy to capture the investment in human capital. Investment in human capital is a significant factor of economic growth in many other regions. The people of

Africa experience lower levels of education than those in other regions of the world, which reflects the lower level of economic development in Africa. As Schultz (1999) argued, Africa also has some of the lowest levels of schooling in the world, and the relative quality of schooling still remains to be evaluated. Thus, I expect education to become even more critical to the economic progress.

“Natural resources” are measured as the percentage of export that is each country’s main mineral commodities. Sachs and Warner (1997) pointed out that one of the surprising features of modern economic growth is that economies abundant in natural resources have tended to grow slower than economies without substantial natural resources. They conclude that high resource wealth has encouraged developing countries to pursue protectionist, state-led development strategies, as they try to combat the

natural resource curse or Dutch Disease³ effect of the resources' abundance. In addition, they argued that this inward-looking approach to development may result in lower investment rates and/or lower growth rate directly.

“The Globalization index” measures how countries are economically, politically, and socially integrated. The sub-indexes of globalization are strongly related to each other, so including them separately in a regression induces collinearity problems. The Globalization index is used to capture the long distance flow of goods, capital, and services and diffusion of government policies and the spread of ideas, information, and people.

³ The Dutch disease is a theory that explains that countries that are wealthy in natural resources tend to have a decrease in manufacturing industries causing them to become less competitive because they neglect those industries—manufacturing or agriculture in the case of Africa. Indeed, manufacturing and agriculture are essential to a country's economic growth.

“The lagGDP” is also included to measure the effect of past GDP. In most countries, past performance has an effect on future economic growth.

All variables, except rule of law, corruption and natural resources, are in current US\$. A group of country dummies are included to control for the effect of different countries' characteristics because the effect of all factors vary across countries but not so much over time, since only a decade is used in this model.

Data is from various sources. GDP, aid per capital, loans, FDI, and trade (export and import) are taken from the World Bank Development Indicators. While the Globalization index is taken from the KOF index Globalization, net enrollment/attendance rates are taken from United Nations Data, mineral commodities from U.S. Geological Survey, Rule of Law index is from the

Worldwide Governance Indicators, and the corruption index is taken from Transparency International.

III. Results

Table 4 in the appendix provides a summary of the variables used in this study. The OLS estimates used in the model are provided below:

$$\begin{aligned} \text{Log GDP} = & 0.1901226 + 0.0003689\text{aid} \\ & \pm 0.0001656\text{loans} \pm 0.0011973\beta\text{3FDI} \\ & \pm 0.000000249\text{export} + 0.0001704\text{import} \\ & + 0.0410666\text{rulelaw} \\ & + 0.0007122\text{humancap} \\ & + 0.0002286\text{naturalresources} \\ & + 0.000702 \text{ Global index} \\ & + 0.9964942\text{LagGDP} \pm 0.0276172\text{Corrupt} \\ & + \epsilon \end{aligned}$$

(2)

The results from the model used here indicate that this study is consistent with other economic studies of economic growth. The result for globalization index indicates that globalization has a positive coefficient (0.000702), but a statistically insignificant effect ($p=0.477$) on the economic growth in Sub-Saharan Africa. This is

consistent with the findings of other studies, which have established that globalization is not fully grasped by all of Africa. This suggests that globalization is important for economic growth in Africa but is performing below its potential. Otenyo (2004) argues that one positive effect of globalization is the drive toward greater decentralization and openness. But African nations with large amounts of natural resources tend to lean toward protectiveness, which results in a slower growth rate.

I tested whether the globalization index has different effects in countries that have large amounts of natural resources in comparison to countries that do not. I ran a regression with economic growth measured here by $\log \text{GDP}$ of year one minus $\log \text{GDP}$ of year two against lag trade, which is the past term of trade, and lag global, which is the past globalization index. I created a dummy variable with countries that export 40 percent or greater of their natural

resources in comparison with countries that export less than 40 percent of their natural resources. I also used the fixed effect for this model. The results show (see table 3) that in countries with a large amount of natural resources, globalization is not statistically significant ($p\text{-value}=0.73$) to economic growth. But in countries with less than 40 percent of natural resources, globalization is statistically significant ($p\text{-value}=0.011$) to economic growth. This suggests that globalization is statistically significant for economic growth in countries with “scarce” natural resources; but in countries abundant in natural resources, globalization is positive, but statistically insignificant.

The result for foreign aid has a positive coefficient (0.0003689) and is statistically significant for economic growth ($p=0.005$) of African countries. A dollar increase in aid per capita will increase GDP by .0369 percent. Among

scholars, aid is one of the major conventional investments that are deemed to foster economic growth (Papanek, 1973).

The coefficient for loans is negative (-0.0001656) and p-value (0.129). This means that there is a negative relationship between loans and economic growth, but it is statistically insignificant. Many other scholars such as Dreher (2006) have demonstrated that there is a negative relationship between loans and economic growth. This relationship is due to the fact that loans often lead to debt. This study provides further proof of this.

The results showed negative coefficient (-0.0011973) between foreign direct investments (FDI) and economic growth and statistically insignificant (p-value 0.083) at the 5% level, controlling for all other variables. According to Asiedu (2005), among developing countries as a whole, FDI flows have increased from 17 percent in the second half of 1980s to 32 percent in 1992, but the share of Sub-Saharan

Africa is now below 1 percent and falling. Asiedu (2005) also mentioned that an increase in FDI does not necessarily imply higher economic growth. Indeed, the empirical relationship between FDI and growth is unclear.

In this model, I separated imports from exports because I wanted to understand their respective effects on economic growth. The terms of trade as percentage of GDP was negative to economic growth, this is often due to trade deficits. Many African countries have a negative trade deficit because they import much more than they export. Hence, the negative relationship between the terms of trade and economic growth. Most countries export only primary commodities or natural resources. The result from this study shows that there is a negative coefficient (-0.000000249) between import and economic growth, but not statistically significant (p-value 0.996) at the 5 percent level. There is a positive coefficient (0.0001704) between economic growth

and exports, but it is statistically insignificant (p-value 0.716). This is what I expected and is consistent with other studies. According to Meagher (2003), Africa's share in world export flow has fallen, particularly in manufacturing, which is the key growth sector for the expansion of trade and resource flows in the context of globalization. In addition, Meagher (2003) concludes that in the face of declining exports and international investment Africa has fallen far behind in the development of the appropriate infrastructure, technology and skills to link up with the information revolution, which is central to the global restructuring of production, trade, and finance.

The rule of law coefficient is positive (0.0410666) and statistically significant (p-value 0.011) at the 5 percent level. This is important because political accountability is important to economic growth. However, there is a negative coefficient (-0.0276172) between corruption and economic

growth, which is what is expected from such study.

Corruption is negative and statistically significant with a p-value of 0.002. This indicates that a 1 point increase in corruption will decrease GDP by 2.76 percent which is significant. Corruption affects economic growth by reducing aid, foreign investment, and effectiveness in an economy.

Otenyo (2004) used Tanzania and Kenya as examples, where Tanzania lost aid due to bureaucratic corruption and Kenya lost a great deal of its competitiveness due to massive corruption in the government. For many years, Kenya has been among the worst performers on Transparency International (TI) Corruption Perception Index (CPI) which is the index employed in this study.

I expected investment in human capital to be positive and statistically significant. Investment in human capital here measured the net enrollment of primary education rate over a 10 year period, which is not enough to make a conclusive

decision. The coefficient is negative (-0.007122) and statically insignificant (p-value 0.088). As mentioned before, Africa has some of the lowest levels of school enrollment in the world.

Natural resources are measured as the percent of exports that are a main mineral resource of each country. African countries on average depend on primary product exports (86 %) (Barbier, 2005). The results from this study show a positive relationship between economic growth and mineral resources. The coefficient is .0002286 and statistically insignificant to economic growth with a p-value of 0.258 at the 5 percent level.

IV. Discussion

Many of the results presented in this study are consistent with other economic studies. Globalization, although positive for economic growth, is not significant in Africa because globalization is not fully realized there. The

main goal of this study has been to investigate the effect of globalization relative to other traditional factors such as aid, FDI, and trade on the economic growth of Sub-Saharan Africa. The results indicate that globalization can positively impact economic growth; however, it is not statistically significant for all of Africa in this study. Many studies conclude that the lack of economic growth in Africa is due to marginalization of the world economy, lack of globalization, heavy dependence on primary commodities and/or natural resources, as well as weak technological capabilities. Thus, African nations not fully integrated to the global economy. Globalization can work in African nations if it is used to promote embedded, decentralized, broad based trading networks that bypass current trade patterns dominated by transnational oligopolies and corrupt African elites (Schneider, 2003).

Globalization can be a catalyst for economic growth. Most countries that are well off in Africa, such as the Seychelles, are countries with little or no natural resources. Botswana is a great example of a country in Sub-Saharan Africa that did not fall victim to the natural resource curse (or Dutch disease), but instead manages its natural resources to its benefit. In essence, countries such as Botswana and Seychelles have embraced and managed globalization. As Schneider (2003) found in his study, in an effort to manage globalization and diversify its economy, while fostering greater global linkages for the benefit of its citizens: the government of Botswana followed the classical neoliberal recommendations for developing an economy. They established an appropriately valued currency, political and social stability, lowered wages, subsidized and taxed financing and training, and provided good education and infrastructure. They learned from the experience of South

Korea because taxes and subsidies were accompanied by requirements that firms employ at least 400 Botswana workers, invest 25 percent of the project's capital, and export most of what is produced (Schneider, 2003: 5). By reinvesting wealth of natural resources in physical and human capital, for instance, Botswana gained one of the highest rates of primary and secondary-school enrollment (Barbier, 2005). There are ways in which Africa might benefit from globalization significantly, perhaps by taking examples from Botswana, Seychelles or East Asian such as South Korea, Taiwan, Singapore, and Hong Kong when it comes to the process of globalization. However, policies that are followed need to be country-specific.

Most African countries export natural resources or primary commodities which were conditions attached to SAPs. This study shows that globalization is not important to economic growth of countries with large amounts of natural

resources. Sachs and Warner (1997) pointed out that high resource abundance leads to increased aggregate demand that shifts labor away from high learning-by-doing sectors and thus depresses growth in labor productivity. In other words, natural resource production is less skill intensive than other industries. Therefore, when countries open to trade, they shift away from manufacturing, which requires skilled labor to primary production which require less skilled labor.

Globalization does foster economic growth in manufacturing and infrastructure, argued KS and Reinert (2005). However, in most African countries, the manufacturing industries are neglected. Instead, they import cheap manufactured goods from Asia which undermined the industries at home.

Meagher (2003) also concluded that the flood of cheap Asian manufactured goods imported via trans-border trading circuits has crippled manufacturing industries throughout West Africa. Another sector that has been neglected is the

agricultural sector. Trans-border inflows of agricultural commodities undermine the long-term viability of local agriculture by undercutting prices and eroding demand, in addition to undermining local food security and disrupting agricultural development initiatives (Meagher, 2003). In order for Africa to benefit from globalization it must embrace other sectors such as agricultural and manufacturing industries.

The result of FDI from this study found a negative relationship. In economic literature, there are controversies over the benefit of FDI. Some found a positive relationship, others concluded that FDI enhances growth only under certain conditions. For example, when the host country's education exceeds a certain threshold, or the domestic and foreign capital are complement, the country has achieved a certain level of income, the country is open, or when the country has a well developed financial sector (Asiedu, 2005).

Other scholars found that FDI is largely driven by natural resources and markets' sizes. This seems to be consistent in Africa. The three largest recipients of FDI are Angola, Nigeria, and South Africa. As mentioned above, private investment that occurs in mineral resources is not beneficial in the long run because it is not channeled to human capital or infrastructure. Another problem regarding natural resources in Africa that is not often discussed is that natural resources are often owned and managed by foreign capital. This is another reason why natural resources have not been an engine for economic growth. Jomo K.S. and Erik Reinert (2005: 124) argue that "international capital flow (FDI) often does not contribute to growth because they tend to be primarily concentrated in enclave sectors, and in primary and extractive industries that exacerbate the pattern of comparative advantage." They conclude that foreign capital plays a positive role in economic growth when it goes into

manufacturing and infrastructural sectors and not into primary production sectors. In Africa, FDI often goes into natural or primary resources, which do not play an important role in economic growth.

In comparing developed countries to developing countries, only 2 percent of national wealth is generated through dependence on primary commodities, whereas for developing countries dependent on export revenues from primary commodities, about 20 percent of their national wealth comprises natural resources (Barbier, 2005). Barbier (2005) concluded that poor economies that can be classified as highly resource-dependent in terms of primary product exports also show low or stagnant growth rates. Thus, there is more than enough evidence to show that resource dependency may be associated with poorer economic performance. In Africa, greater dependence on the exploitation of natural resources appears to hinder economic

growth. There are many other proposed hypotheses as to why natural resource dependency hinders economic growth. In Africa, this can be attributed to failed policies, weak institutions, lack of well-defined property rights, insecurity of contracts, corruption, and social instability (Easterly and Levine, 1997; Warner and Sachs, 1997). However, other economists propose that the problem might be due to a failure to ensure that the rents generated from natural resource extraction are reinvested in other forms of capital such as those that are human, physical and knowledge-based in order to sustain economic growth in resource-rich countries, a phenomena known as the Hartwick rule (Barbier, 2005).

Countries with natural resources, especially in Africa, are prone to problems such as corruption, and thus are unable to manage natural resource assets (and globalization) efficiently in order to generate net benefits. This problem

will continue to hinder economic performance. Figure 1 shows that countries with large amounts of natural resources tend to be highly corrupt, with the exception of Botswana, which is a unique case. There is a correlation between natural resources and corruption. For example, Nigeria is a nation with large amounts of natural resources, especially in oil. Yet it is also one of the most corrupt countries in the world. Countries such as Mauritius, which do not have a large amount of natural resources, are less corrupt, highly globalized, and have higher economic growth.

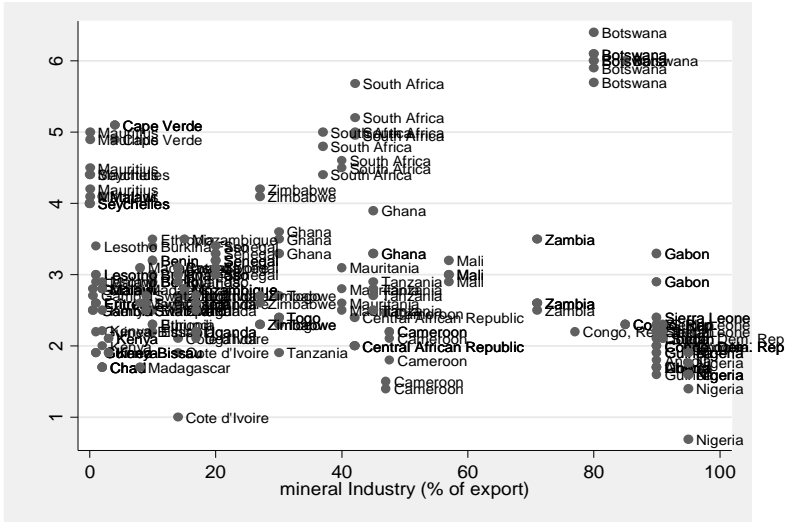


Figure 1: Countries mineral exports in relation to the corruption (CPI) index

Dreher (2003) concluded that globalization is good for growth. He found that on average, countries that globalize experience higher growth rates, especially economically integrated countries. Thus, the accusation that poverty prevails because of globalization is therefore not valid, unless of course, globalization is not managed. On the contrary, those countries with the lowest growth rates are those that did not globalize. However, it is not enough to

simply globalize in order to stimulate growth and reduce poverty according to Dreher (2003). This study shows that countries that are more globalized tend to be less corrupt and countries that are less globalized are highly corrupt. This can be seen in Figure 2 where the lower the number, the more corrupt the country is, 1 being the most corrupts and 6 being the least corrupt. On the globalization index, the higher the number, the more globalized the country.

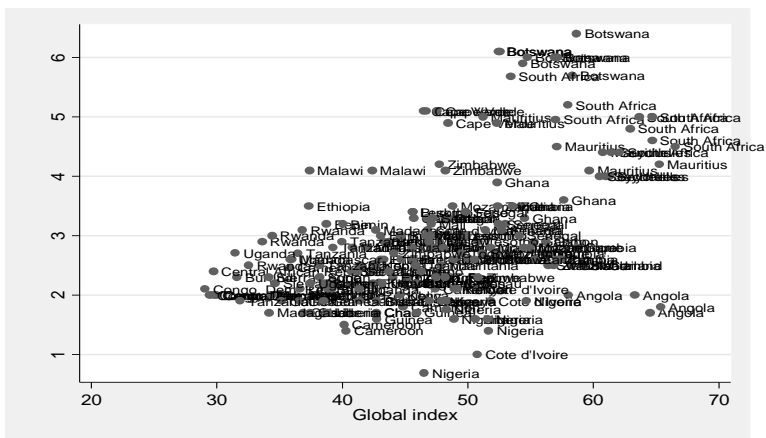


Figure 2: Countries globalization index in relation to the corruption (CPI) index

Globalization is also a means to achieve good governance. Otenyo (2004) concludes that the potential of globalization as a catalyst in governance is an important dimension in regional development. Due to corruption, Africa has not excited western investors as other regions have. Capital inflow remains low and so the total picture of Africa's place in a globalizing world remains peripheral. Easterly and Levine (1997) have empirically demonstrated that economic growth is affected by the quality of governance. Otenyo (2004) also stated that most data shows a positive correlation between globalization and the rate of attention to political accountability reforms. The results from this study support this finding. Countries that are globalized not only foster good governance, but attract trade, investment, and tourism, which in turn generate greater economic growth.

Globalization is also meant to provide physical infrastructure, technological support, and appropriate incentives necessary for a country to grow in the long run. One of the sad problems in Africa is that the most educated and skilled individuals migrate to developed nations such as the U.S.A, Canada, and the United Kingdom (Ajayi, 2003). Globalization is a means of providing technology to Africa, but this technology can only be successfully acquired, utilized, and diffused if countries have developed sufficient social absorptive capacity, such as human capital. Education is therefore one of the keys to economic growth. Asia has been publicized as the world's economic miracle, opening and liberating trade regimes which have allowed these countries to develop their comparative advantages and gain access to newer and more appropriate technologies. Financial liberalization has increased their access to international private capital, not to mention more influence

and power in the international economy (Ajayi, 2003). There is much that Africa can learn from the Asia model, in particular its development strategy. One of the investments that have helped developed Asia is its investment in education. Countries that are globalized tended to have higher levels of education.

Globalization can significantly benefit Africa if Africa positions itself appropriately via appropriate policy measures. Like Asia, Africa needs to manage globalization in order to benefit from it, instead of being managed by globalization.

V. Conclusion

This study concludes that although globalization is not statistically significant to economic growth in Sub-Saharan Africa, it can have a positive influence on its economic growth. Although the playing field in the international economy is not level, African countries must

take the necessary steps to reevaluate macroeconomic policies and establish international institutions to better manage and reap the net benefits of globalization. With good governance, better institutions and sound and stable macroeconomic policies, Africa can better manage its natural resources, attract more capital inflow, and benefit greatly from globalization.

Increased integration into the global economy can provide Africa with newer and more efficient technologies to build other industries such as agriculture and manufacturing, and to reinvest natural resource revenues into these industries. In addition, globalization can foster greater investment in infrastructure, reduce corruption and improve the rule of law, all of which are essential to economic growth. Globalization can pressure nations to stay politically moral, and develop better political and legal institutions. Most economists strongly advocate globalization because of

its positive net benefit to economic growth. Globalization increases competition, fosters innovation and efficient production, promotes education and infrastructure, but most importantly encourages economic diversification. African nations can follow the models of East Asia by diversifying their economies and industries through reinvesting their natural resource rents and revenues.

There is good evidence for further research in the future. The model might suffer from the problem of panel data regression. Increasing the number of years to greater than 30 years would create more satisfactory results. Also, it would yield better results to avoid some of the statistical errors and include more variables. In addition, the study would benefit by including more African countries perhaps by comparing African globalization processes to those in other regions of the world.

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THE TREND OF THE GENDER WAGE GAP OVER THE BUSINESS CYCLE

Nicholas J. Finio

Abstract

Even after the close of the first decade of the 21st century, there is still significant gender bias in labor market composition and compensation. As the events of the last two years have proven, even drastic efforts of monetary and fiscal policy have not tamed the business cycle. Previous research has reached no definite conclusions on the effect of business cycle trends on the gender wage gap. Over the period from 1979:1 to 2009:3, it is found that increases in the growth rate of GDP yield decreases in women's earnings relative to men's, and it is also found that increases in the unemployment rate yield increases in female earnings relative to male. It is hypothesized that these significant differences in compensation over the trend of the business cycle correspond to inherent differences in the labor supply curves of men and women.

I. Introduction

In the post-war period, as women have entered the workforce in the United States in ever greater numbers, they have made substantial gains in earnings relative to their male peers. However, by one metric, women are currently earning only 80% of what men earn (BLS 2009). This can be thought of as a 20% “gender wage gap,” which has varied extensively over the previous fifty years, with a general trend of convergence to a smaller gap. For comparison, the wage gap was around the 35-37% range through the 1960s and early 1970s (O’Neill 1983).

An extensive body of literature exists which investigates the structural composition of this gender wage gap, attributing the differences to skill premiums, sexual discrimination, and various other factors. The goal of this paper is not to analyze the determination of the wage gap,

but to conduct a time-series analysis of the effect of the business cycle in the United States on the gender wage gap.

The reason for conducting this analysis is multifaceted. Foremost, the literature studying the effect of the business cycle on the gender wage gap is inextensive, and outdated. A new paradigm may have indeed developed in labor markets over the past 15 years, since the last substantive review of the impact of the business cycle on the wage gap. The labor market in the US is still suffering from the effects of the 2007-2009 global recession, with the unemployment rate reaching, and only recently declining from, a 10% level. Unemployment rates of this magnitude have not been seen for a quarter century. Additionally, a significant portion of the job loss during this recession has come in the manufacturing, and construction industries, both traditionally industries dominated by men (Kandil 2002).

Given the significant structural shifts in the economy, and dynamic factors in the labor market, there is reason to believe that the gender wage gap may be significantly shifting in the current period. Indeed, with the current unemployment rate for men standing at 10.8%, and the female rate standing at 8.3% (BLS 2009), it is difficult to ignore speculation about the impact of such significant differences in the male and female labor supply on relative compensation.

In the following section I will describe several methods of investigating the changes in the wage gap over the business cycle, specifically with reference to O'Neill, and Kandil and Woods. Section III will detail my methodology for approaching this topic from a new angle. Section IV will discuss in detail the specificities of the data used to conduct this analysis, and section V will present the results of testing the model using the given data. I will then

conclude with a summary and suggestions for policy and further research.

II. Literature Review

As aforementioned, the existing literature discussing the problem at hand is thorough, but outdated, and differing in specifics from the planned approach herein. Two main streams of thought, emerging from two specific papers, have emerged from the work on the gender wage gap trend. First, and most outdated, is the idea that business cycle fluctuations adversely affect women in terms of wages. Several authors have conversely found that male and female labor supply curves are becoming more similar over time, resulting in a general convergence of the wage gap; this wage gap convergence is exaggerated by the business cycle.

June O'Neill, publishing "The Trend in the Male-Female Wage Gap in the United States," conducted a time-series analysis, focusing on the effects of cyclical changes in

unemployment in the wage gap. She theorized that business cycle fluctuations in unemployment may affect the wage rates of men and women differently for two reasons: (1) women's wages are less likely to be covered by union wage agreements than men's, which makes them more flexible, which would increase female employment stability but *widen* the wage gap during a recession (and opposite during an expansion); (2) within industries and occupations, women have less specific training, which results in greater vulnerability during layoffs for female employees (O'Neill 1985). O'Neill found results that matched her expectations: specifically that an increase in the unemployment rate caused a decrease in the female-to-male earnings level, at a statistically significant level.

Magda Kandil and Jeffrey Woods sought in 2002 to extend the work of O'Neill in their work "Convergence of the gender gap over the business cycle: a sectoral

investigation,” with sectoral wage data from 1979:1 to 1993:4, and different theory. The authors theorize that men do indeed have a relatively inelastic labor supply curve, due to significant investment in training because of long-term labor force obligations. This incentivizes men to endure wage relative to employment fluctuations over time.

Females, who invest fewer years of experience and tenure in the labor force relative to men, are caused to endure more employment compared to wage fluctuations over the business cycle. Given this framework, the authors expected that the wage gap would widen significantly during expansions, and shrink during contractionary periods (Kandil 2002). These expectations are contrary to those of O’Neill.

Empirically, Kandil and Woods found evidence of wage convergence with the business cycle in a majority of the eight sectors. The gap between men’s and women’s wages appears to be shrinking over time, due to a decline in

responses of the hourly wage gap for males relative to females during expansionary and contractionary demand shocks. The authors assert that the labor supply curves of the two genders are become more similar over time, resulting in wage convergence over the business cycle (Kandil 2002).

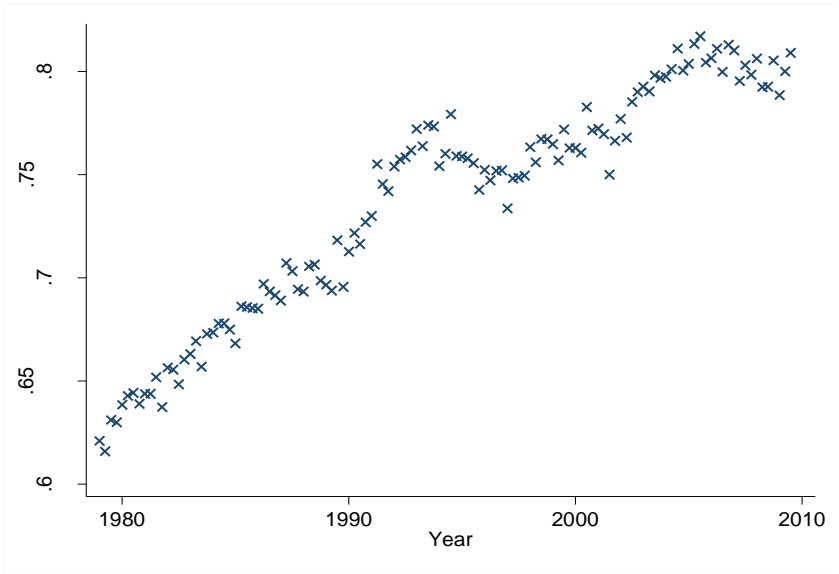
Two additional international studies, one by Aller and Arce in 2001, and one by Gupta, Oaxaca, and Smith in 2006 find similar empirical results, using similar theory to that of the Kandil and Woods study.

III. Methodology

This econometric analysis seeks to answer the following question: does the female-to-male earnings differential expand or contract during business cycles? More specifically, how do fluctuations in the growth rate of GDP, and fluctuations in the unemployment rate affect the female-to male earnings differential?

Theory, as discussed, shows conflicting evidence for the composition of the male-female earnings differential over time as affected by the business cycle. Indeed, a brief investigation of a scatter plot of the differential over time (Figure 1) can show just how variable the wage gap has been since 1979.

Figure (1): The Gender Wage Gap over Time (Quarterly Observations)
US Bureau of Labor Statistics



This time series trend of the wage differential will be used as a dependent variable in an OLS regression designed to measure the impact of fluctuations in aggregate demand and supply and labor demand and supply on the wage differential. Specifically, the model will take the form of Equation (1), below:

$$Y = \beta_1 + \beta_2 \Delta GDP_t + \beta_3 \Delta GDP_{t-1} + \beta_4 \Delta GDP_{t-2} + \beta_5 U_t + \beta_6 U_{t-1} + \beta_7 U_{t-2} + \beta_8 t + \beta_9 t^2 + \varepsilon$$

Where Y is the female-to-male wage differential, GDP is the real level of GDP in the current quarter, U is the current nominal unemployment rate, t is a time trend, and ε is a stochastic error term. The current quarter in time is represented by t , and previous quarters are represented by $t - n$. In addition to the CLRM OLS regression that will be conducted, the Prais-Winsten (Cochrane-Orcutt) iterated autoregression will be utilized to correct for autocorrelation in the error term.

Theory suggests that wages are sticky, such that, aggregate demand and supply shocks will not immediately affect worker wages due to worker bargaining agreements. This is the rationale for including lagged terms for the change in GDP, as it is unreasonable to assume that GDP growth in the current quarter determines the level of wages in the current quarter. By similar reasoning, the current unemployment rate will not influence the labor supply curve and effect wages contemporaneously.

An augmented Dickey-Fuller test for stationarity on the dependent variable leads to non rejection of the null hypothesis of a unit root contained in the dependent variable. The wage differential does not follow a stationary process. Because of the non-stationarity of the dependent variable, two time trends are included in the model: a linear term, and a quadratic term. Results from the Dickey-Fuller test are available in Table (1).

Table (1). Dickey Fuller Test for Stationarity of the Female-to-Male Wage Differential.

Dickey-Fuller test for unit root	Number of observations = 122			
	----- Interpolated Dickey-Fuller -----			
Test	1% Critical	5% Critical	10% Critical	
Statistic	Value	Value	Value	

Z(t)	-1.672	-3.503	-2.889	-2.579

MacKinnon approximate p-value for Z(t) = 0.4454				

The model of the female-to-male wage differential is designed to specifically analyze the impact of aggregate economic shocks on it. These shocks are specifically limited to aggregate demand, in the form of GDP growth, and labor supply, in the form of the unemployment rate. Two time trends are included to break the trends in the dependent variable. Theory suggests two possibilities for empirical results: namely, that the female-to-male wage differential could *increase* during contractions (as empirically shown by O’Neill), or that the female-to-male wage differential could *decrease* during contractions (as empirically shown by

Kandil and Woods). Notably, O'Neill did not include measures of shocks to aggregate demand and supply, only the unemployment rate as a measure of the business cycle. Kandil and Woods did not include unemployment rates in their analysis, only proxies for aggregate demand and supply. Furthermore, the results of the most recent study only date to 1993, resulting in an additional sixteen years of time series data being available for study in regards to the composition of the wage gap. In the next section, changes in that data since 1993 will be discussed as they pertain to the analysis.

Simultaneity bias is not an issue for the regressions at hand; theory does not suggest that the wage gap's nominal size has a causation effect on the growth rate of GDP or the unemployment rate. There is no need for instrumentation or two stage OLS correction of the model in its current functional form.

IV. Data

Ideal data for this time series regression would date back to the second world war, when women began to enter the “official” workforce in significantly greater numbers. By the nature of the gender wage gap itself, constructing data for this analysis presents problems, as noted earlier in the discussion of the non-stationarity of the wage gap dependent variable. Because the rate of female participation in the labor force has fluctuated greatly over time, results in any given period may be significantly different from another. Furthermore, the feminist movement, equal pay legislation, and shifting cultural attitudes obviously have significant (and difficult to quantify) effects on the wage differential. Given these issues, a practical aggregate measure of wages was selected.

The data on the gender wage gap was constructed from the Bureau of Labor Statistic’s Current Population

Survey. Two time series dating back to 1979:1 and ranging to 2009:3 were obtained, the seasonally adjusted median usual weekly earnings (averaged by quarter), for each sex. This series applies only to full-time workers, removing bias of ratios of each sex that work part time to full time. From these two series, the dependent variable in the model, the female-to-male earnings ratio, was constructed. This was done by dividing female earnings in each quarter by the corresponding level of male earnings. Figure (1) in section III illustrates the composition of the dependent variable over time. As shown, the average wage differential, by quarter, over the time period 1979:1 to 2009:3, was equal to 73.6%, interpreted as women making that percentage of what men make, on average. The values for the differential vary widely over the 30 year period, ranging from nearly 60% to above 80%.

The first independent variable in the equation is the growth rate in GDP. The time series for this was obtained from the Federal Reserve Bank of St. Louis' FRED online database. The data takes the form of the seasonally adjusted continuously compounded annual rate of change in real gross domestic product. Two lagged terms of this variable were created, dating back one quarter, and two quarters, respectively.

Additionally, the unemployment rate is included as an independent variable in the regression. This data was obtained from the BLS's online database, consisting of the seasonally adjusted quarterly unemployment rate, ranging from 1979:1 to 2009:3. Two lagged terms were also created for this variable. A table of summary statistics for all included model variables is available below, in Table (2).

Table (2): Variable Summary Statistics

Variable	Mean	Std. Dev.	Min	Max	# Obs
Y	.736	.055	.615	.817	123
ΔGDP_t	2.622	3.039	-8.3	8.9	123
ΔGDP_{t-1}	2.622	3.039	-8.3	8.9	123
ΔGDP_{t-2}	2.615	3.050	-8.3	8.9	122
U_t	6.148	1.484	3.9	10.7	123
U_{t-1}	6.148	1.484	3.9	10.7	123
U_{t-2}	6.120	1.456	3.9	10.7	122
t	62	35.651	1	123	123
t^2	5104.667	4653.386	1	15129	123

V. Empirical Results

The following, Table (3) presents the results for the OLS regression on Equation (1), as detailed in section III.

There are no statistical modifications to this model.

Table (3).
 Time-Series OLS Regression of the Gender Wage Gap,
 1979:1 – 2009:3

	Y	
	Coefficient	Absolute value of t-statistic
ΔGDP_t	-0.001	(2.50)*
ΔGDP_{t-1}	-0.002	(3.12)*
ΔGDP_{t-2}	-0.001	(1.49)
U_t	-0.014	(2.34)*
U_{t-1}	0.001	(0.07)
U_{t-2}	0.018	(3.08)*
t	0.003	(19.92)*
t^2	-0.000	(9.71)*
Constant	0.591	(63.19)*
Observations	121	
R-squared	0.96	
* significant at 5%		
Durbin-		
Watson		
Statistic	.911	

When interpreting this regression it is first necessary to note the presence of positive autocorrelation in the error term, as evidenced by the Durbin-Watson statistic being of lower value than its lower bound. This suggests a statistical correction will be necessary for more robust results.

Furthermore, a Breusch/Pagan test for heteroskedasticity yields a p-value of .9283, indicating no rejection of the null hypothesis of constant variance of the error term. However, the regression coefficients can still be interpreted.

The Ramsey RESET test yielded a p-value of 0.000, allowing rejection of the null hypothesis that there are omitted independent variables of a squared or polynomial form in the model specification. This result is consistent with the structure of theoretical model of the behavior of the wage gap, and it also fits with the inclusion of only a squared term for time in the model. Investigation of the variance inflation factors, seen below in Table (4), necessitates some discussion. There is some issue with multicollinearity in the regression, especially due to the time series inclusion of lags on macroeconomic variables. Furthermore, there is significant multicollinearity between a variable and its squared values. However, theory suggests that the inclusion

of these variables is necessary, even given the high multicollinearity; dropping any variables would lead to specification bias.

Table (4): Variance Inflation Factors

Vari	ΔGDI	ΔGDP_t	ΔGDP_t	U_t	U_{t-1}	U_{t-2}	t	t^2	Me
able									<i>an</i>
VIF	2.3	2.40	1.76	74.	168	67.	25.	23.	45.
	1			85	.93	63	82	38	89

The coefficient value on GDP and its one period lag were both found to be statistically significant in difference from zero, and negative. This supports the empirical results of Kandil and Woods (2002), which also discovered that an increase in GDP corresponds to an increase in the percentage value of the female-male wage differential (i.e. the female-to-male wage ratio would decrease).

The coefficients on the current value of unemployment, and the two-period lag value of unemployment were both found to be statistically significant in difference from zero. However, they took opposite signs, with the current value of unemployment's coefficient yielding a positive sign, suggesting that an increase in unemployment will increase the value of the female-male wage differential (as above with GDP). This supports the empirical results of O'Neill, 1985, who found the same. However, as the coefficient on the two-period lag in unemployment is also statistically significant in difference from zero, it must be interpreted. It suggests that an increase in unemployment, two quarters previously, will decrease the value of the wage differential, which supports the conclusions of Kandil and Woods, and Aller and Arce (2001), which both found that the gender wage gap contracts during recession.

As predicted by the non-stationarity of the wage gap over time, the included variables of time and time squared both had statistically significant coefficients. This time-series significance explains the high r^2 value of the regression, which is of little use for interpretation of the model in this case. To correct for potential error, mostly due to the detection of autocorrelated errors, the Prais-Winsten iterated autoregressive estimates of the same regression equation will be calculated. This regression will also utilize robust standard errors, autocorrelation issues in the error term. The results from this regression are presented below, in Table (5).

Table (5).
Prais-Winsten Autoregression of the Gender Wage Gap,
1979:1 – 2009:3, with robust errors

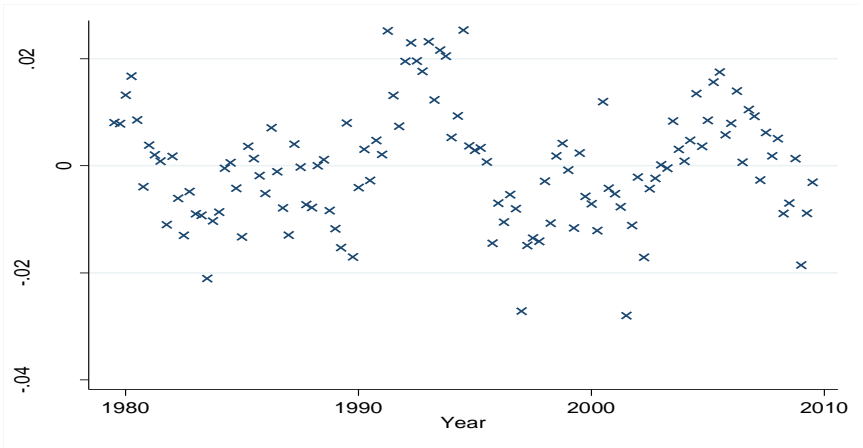
	Y	
	Coefficient	Absolute value of t-statistic
ΔGDP_t	-0.0004	(1.23)
ΔGDP_{t-1}	-0.0009	(2.38)*
ΔGDP_{t-2}	-0.0002	(0.76)
U_t	-0.0066	(1.57)
U_{t-1}	0.0000	(0.02)
U_{t-2}	0.0108	(2.53)*
t	0.0028	(11.84)*
t^2	-0.0000	(5.45)*
Observations	121	
R-squared	0.91	
* significant at 5%		
Durbin-Watson Statistic	2.31	

First notable in the results of the AR(1) model is the transformed Durbin-Watson statistic, which is not proof of no autocorrelation, but significantly close to its upper bound of no autocorrelation as to assume that autocorrelation is not an issue here (especially when compared to the original statistic of .91). Another method of testing for autocorrelation is the runs test for patterns in the sign of the

error term. The runs test on the errors from the AR model yields a rejection of the null hypothesis of non serially random errors, indicating that autocorrelation is still present (the runs can actually be seen in Figure (2)).

Investigation of the behavior of the residuals for the AR(1) regression over the time period is still warranted, and this can be observed in the scatter plot in Figure (2), below.

Figure (2). AR(1) Regression Residuals.



The error term for the autoregressive does not appear to be entirely stochastic in nature. At a quick glance, the residuals appear to reflect the business cycle, to some extent. However, although there appears to be a slight pattern in the error term, the Durbin-Watson statistic does not yield definite conclusions about autocorrelation. Further investigation into this problem suggested utilizing differencing of the dependent variable with the current RHS variables: however, this method garnered no statistical significance from zero of any RHS coefficient.

Accepting the issues with this regression as given, interpretations of the coefficients can be made. For the GDP coefficients, in this regression, only the one-quarter lagged coefficient on GDP is deemed to have an effect statistically significant in difference from zero, taking a negative value, matching the results of the OLS model and supporting the evidence from Kandil and Woods (2002). These results

suggest that when there is a positive increase in the growth rate of GDP in the previous quarter of one percent, there is a .0004 increase in the percentage value of the gender wage gap (i.e. it would increase from 20% to 20.0004%, or, in terms of the regression model, the percentage of men's wages women earn would drop from 80% to 79.9994%), holding the influence of other included variables constant. While the t-score on the non-lagged component of GDP's coefficient has dropped, its sign has not changed, so conclusions from the previous section about the impact of GDP on the wage differential are not changed.

The only coefficient on unemployment that remains statistically significant is the two-period lagged value, which takes a positive coefficient again, as in the OLS regression. This coefficient predicts a .0028% decrease in the value of the gender wage gap for each increase in the unemployment rate of 1%, holding the influence of other included variables

constant. This supports the empirical work of Kandil and Woods, and Arce and Aller, who found the gender wage gap to contract during a recession. The negative coefficient on the current value of unemployment is no longer statistically significant in difference from zero, which indicates that the results of O'Neill are not supported by the autocorrelation corrected regression. The coefficients on the time variables remain statistically significant in difference from zero, as predicted by theory.

VI. Conclusions

This investigation focused on the behavior of the female-to-male wage differential in the aggregate US economy over the period 1979:1 to 2009:3. An estimation of the true gender wage gap was created from Current Population Survey data, using median weekly earnings of full time workers. The historical time series data shows

significant variance in the wage gap over time. Stationarity of the wage gap series was rejected.

Using traditional OLS methods, and autoregressive methods, the wage gap was regressed on GDP growth and its lags over two quarters, and the unemployment rate and its lags over two quarters. Empirical evidence was found that the gender wage gap expands during business cycle expansions and contracts during recessions. Specifically: when the growth rate of GDP is positive in previous quarters, the value of female earnings decreases relative to men's; when the unemployment rate increases in previous quarters, the value of female earnings relative to men's increases. Some of this empirical evidence conflicts with previous time series analysis, however, this investigation includes an additional 15 years of data compared to the most recent US study.

This evidence is at large consistent with theory regarding the nature of the labor supply curves of women and men. The greater experience, tenure, and bargaining positions men hold due to their longer commitment on average to the workforce (and possibly sex bias), compared to their female peers, puts them in a position which enables more wage gains during expansions (Blau 1997).

This paper was written to conduct further analysis of an important topic that had not recently been studied. It can be observed that the gender wage gap has been increasing during the current recession (Figure 1). The empirical findings of this paper, however, do not support the current fluctuations in the data. The empirical findings suggest that the large increases in the unemployment rate and decreases in the GDP growth rate should have led to a decreased gender wage gap; the data shows that the gender wage gap has increased. However, the empirical findings do support

the notion that it is crucial for women to increase their work experience, and positions in labor agreements, in order to hold the kind of wage bargaining power that men do.

Further investigation into this topic should undertake a sectoral analysis of wages, similar to the study by Kandil and Woods (2002), in order to analyze the different components of the labor market. Although the results of this paper support previous research, the current situation of the wage gap does not reflect what has been empirically shown. Additional time and data may be necessary in future years to show the true effect of the 2007-2009 recession on the composition of the gender wage gap.

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International Graduate Students and U.S. Innovation

Svetoslav Semov⁴

ABSTRACT

This paper attempts to empirically evaluate the contribution of international graduate students to U.S. innovation. The main framework used is a simplified version of the “national ideas production function”. Two econometric specifications are estimated – one in which a time trend is incorporated to observe the short-term relationship between the variables and one in which no time trend is included with the goal of capturing the variables’ long term equilibrium relationship. The results suggest that in the long-term the number of international graduate students significantly (at the 10% level) affects innovative activity. However, when the short-term relationship of the variables is analyzed it is found that the effect of the foreign students is negative and insignificant. This is attributed to the fixed size of graduate programs in the short run and their tendency to expand in the long-run.

⁴ I would like to thank Professor Hu for her help and guidance with this paper.

1. INTRODUCTION

Increases in unfavorable attitude toward immigrants are often observed in the face of rising unemployment and quite expectedly – in the face of threats to national security.⁵ International graduate students, the focus of this paper, are not left unaffected. For example, since the 9/11 attacks applicants for student visas have been required to have an interview at an American consulate.⁶ This has led to delays of several months in order to sit for an interview that lasts a couple of minutes. Furthermore, new laws mandated the tracking of foreign students, regulated the type of research which they can perform and limited their access to certain biological materials (Warwick, 2006).

Such events are particularly alarming given the composition of US S&E doctoral graduates in recent years.

⁵ The most recent example is the Grassley-Sanders amendment, a part of the recent fiscal stimulus package that restricted the ability of recipients of federal money to hire high-skilled foreigners under the H-1B visa program.

⁶ Economist, 2004

In 2000, for example, the foreign-born represented 39 percent of that group. Furthermore, according to the 2000 Census foreigners comprised 47 percent of the US S&E workforce with a doctoral degree. Consequently, people from academia have repeatedly warned that restrictions to the number of foreign graduate student could lead to a crisis in research and scholarship.⁷

Economic theory suggests that there are a number of ways that international graduate students could contribute to US innovative activity and, in turn, to growth (Maskus et al., 2006). First, that is done through their direct impact as important inputs in university laboratories. International graduate students both perform valuable research and offer new ideas. Second, their publications and patents spill over to the broader economy by becoming knowledge for firms

⁷ In 2004, Lawrence Summers warned Colin Powell, then secretary of state, that the decline of foreign students threatens the quality of research coming from US universities (Financial Times, April 8, 2004).

and inventors. Last but not least, scientific discoveries with participation of international graduate students are frequently turned into licensing arrangements for applied product development.

This paper tries to analyze the role of international graduate students in expanding US innovation. It was primarily motivated by the existence of a number of studies arriving at contradicting results when analyzing the contribution of international graduate students to US innovation. For example, an empirical study by Challeraj et al found that a 10% increase in the number of foreign graduate students would raise patent applications by 4.5%.⁸In contrast, Borjas concluded that international students displace native ones and, therefore, might not contribute to innovation (2004).

⁸ Note that patenting activity is the most commonly used proxy in innovation studies (Trajtenberg, 1990). The reasons for that are explained in the Data section below.

The current analysis tries to reconcile the previous contradicting results on the subject by attributing their inconsistency to the different effect of international graduate students on innovation in the long- and short- terms. Hunt made a similar observation concerning skilled immigrants' influence on US innovation (2008). The author demonstrated that any potential crowd-out effects dissipate when the period of analysis extends over ten years. Undoubtedly, a potential finding indicating that foreign graduate students positively affect US innovation in the long term will have huge implications for immigration policy and it will allow for a more careful evaluation of shocks to the number of international graduate students as the one described above.

Five sections follow. The first reviews related literature on the contribution of international graduate students to innovation. The second describes the econometric model that will be used. The third displays the data sources used. The

fourth analyzes the statistical and economic results obtained for the effect of international graduate students on US innovation. The last section summarizes the findings and makes some public policy recommendations.

II. LITERATURE REVIEW

There are two related strands of literature that help build the foundation for this paper: one discusses the contribution of skilled-immigrants to innovation and the other does so for international graduate students. Most of the issues and methodology used in both research areas are quite similar. In both cases the main question of interest is whether skilled-immigration/international graduate students have a positive impact of innovation. In both cases a certain possibility for a crowd-out effect exists in which domestic workers/students are displaced. An overview of some of the results already obtained follows.

As usually done in the literature Kerr et al. use patenting as a proxy for innovation (2008)⁹. Since each patent provides the name of the inventors, the authors use a name-matching algorithm that detects the ethnicity of the inventor. The dependent variable is the log of overall patents by city. The key explanatory variables are the log of the total number of patents by Indian and Chinese inventors. The focus is on the patenting of these two ethnicities because they play a disproportionate role in the H1-B program. The results show that a 10% growth in the H1-B worker population is associated with a 2% increase in patenting. Furthermore, the authors estimate that a 10% increase in the H1-B population is associated with a 0.5%-1% increase in English invention, suggesting a crowding-in effect.

⁹ Note that patenting activity is the most commonly used proxy in innovation studies (Trajtenberg, 1990). The reasons for that are explained in the Data section below.

However, that estimate is not statistically significantly different from zero.

By exploring individual patenting behavior as well as state-level determinants of patenting, Hunt demonstrates the important boost to innovation by skilled immigrants (2008). Again U.S. patents are used as a proxy for innovation. For the individual-level analysis a probit for the probability of having a patent granted is estimated. The main variable of interest is a dummy variable for the foreign-born. The results indicate that immigrants that are working in S&E are 1.4 percentage points more likely to have a patent than domestic workers in S&E. The state-level analysis uses the share of the state's workforce composed of skilled natives and immigrants as a dependent variable and the share of skilled immigrants as the main independent variable. A coefficient of zero on the independent variable would indicate that there is a crowd-out effect as an increase in the number of skilled

immigrant would be offset by a decrease in the number of skilled natives. The author finds that using ten-year differences leads to a small, but statistically insignificant crowd-out effect. Furthermore, Hunt observes that when the length of differences increases, the crowd-out disappears. The coefficient is 0.95 for 50-year differences. This suggests that any potential crowd-out effects disappear in the long-term.

A paper by Chellaraj tries to simultaneously estimate the effects of both groups (skilled immigrants and international graduate students) on innovation. Chellaraj et al. claim that the presence of foreign graduate students has a positive and significant impact on US patent applications and grants awarded to both firms and universities, meaning that international graduate students contribute to US innovation (2008). However, the authors also estimate that skilled immigration, while having a positive impact on innovation,

is not statistically significant from zero. The model used to account for the role of foreign students is a modified “national ideas production function”. Further details on the model are provided below.

A slightly different approach is used by Stuen et al. (2008). The authors explore the contribution of foreign science and engineering students to the creation of new knowledge in the U.S. economy. They estimate the impact of foreign and domestic graduate students on the publications of 2300 science and engineering departments at 100 large American universities from 1973 to 1998. They use fixed effects for each field for each university. The authors’ results suggest that the relative contribution of foreigners and Americans appear to depend on the type of foreign student. Overall, the marginal foreign student is neither clearly better nor clearly worse than the American one. Foreign students contribute more in terms of citations at the elite universities.

However, there are significant variations in the marginal productivity of students across source regions.

Levin and Stephan assert that foreign-born scientists play a disproportionate role in generating knowledge in the USA (1999). They look at six illustrative criteria to evaluate contributions to US science: individuals elected to the National Academy of Sciences and/or National Academy of Engineering, authors of citation classics, authors of hot papers, the 250 most-cited authors, authors of highly cited patents, and scientists who have played a key role in launching biotechnology firms. For each indicator of scientific achievement they determine whether the observed frequency by birth (or educational) origin was significantly different from the frequency one would expect given the composition of the scientific labor force in the United States. The authors used a “goodness of fit” test by computing the chi-square statistics. Only in the instance of hot papers in the

life sciences were they not able to reject the null hypothesis that the proportion was not the same as that in the underlying population. This means that according to the authors foreign graduate students contribute to US science and therefore to innovation.

Borjas implicitly disputes the findings of Chellaraj et al and Levin and Stephan (2005). He claims that foreign students crowd out native ones from graduate programs. He suggests that there might be two types of a crowd-out effect. The first one is within a particular university. The enrollment of an additional foreign student would imply that one fewer native student would be enrolled. The second type of crowd-out effect concerns the incentives natives have to pursue those educational programs where foreign students cluster. Such a cluster might indicate lower wages in that particular occupation, making natives avoid the program. Borjas focuses on the first type of crowd-out effect. He empirically

verifies that foreign students limit the opportunities available to white men in graduate education, especially at the most elite universities. However, the author admits that the implications of his finding vary on what happens to the displaced white men and to the foreign students after they graduate – questions without a definite answer.

Using a similar approach to Chellaraj's this paper attempts to unify the contradicting claims about international graduate students made in the existing literature. In other words, it tries to explain why some studies imply a positive relationship between international graduate students and US innovation and why others imply a negative one. Just as Hunt's analysis demonstrated the different impact of skilled immigrants on innovation in the different time periods, this paper tries to do so for international graduate students. An attempt is made to find an explanation that compromises the positive findings of Chellaraj et al and Levin and Stephan on

one hand and the negative ones by Borjas and Stuenkel on the other hand. In particular, the negative correlation between international graduate students and innovation is interpreted as the short-term effects of those students on innovation, while the positive relationship is seen as the true long-term connection between the two. The two time-horizons are empirically estimated.

III. MODELING

The contribution of international graduate students to US innovation can be only estimated on the background of some general framework aiming at explaining innovation. Usually the model used to estimate innovative activity is the widely recognized “national ideas production function” (Porter and Stern, 2001; Stern et al., 2002)¹⁰:

$$A_t = \delta (H_t^{INF} H_t^{CLUS} H_t^{LINK}) H_{A,t}^\lambda A_t^\phi$$

(a version of the model used by Porter and Stern).

¹⁰ Note that most of the models described in the Literature Review section use some simplified version of this model.

This framework suggest that the rate of new ideas production is a function of the total capital and labor resources devoted to the ideas sector of the economy - $H_{A,t}^\lambda$, the total stock of knowledge held by an economy at a given point in time - A_t^ϕ , the level of resource commitment and policy choices that make up the innovation infrastructure - (H_t^{INF}), the environment for innovation in the country's industrial clusters - H_t^{CLUS} and the strength of linkages between the common infrastructure and the industrial clusters - H_t^{LINK} . According to Porter and Stern (2001) A_t^ϕ , $H_{A,t}^\lambda$ and H_t^{INF} are fairly easy to quantify. However, the environment for innovation and the linkages between the common innovation infrastructure and the industrial clusters are hard to measure directly.

Because of the limitations outlined above and because of the focus placed on one particular factor in determining innovative activity – the number of international

graduate students – a fairly simplified model is offered. It attempts to capture on one hand the effect of international graduate students and on the other all other relevant factors listed above. The model used is an autoregressive process:

$$A_t = A_{t-1} H_{A,t}^{\lambda F}$$

In other words, innovative activity in time period t is represented as a function of innovation in the previous time period and the flow of international graduate students, $H_{A,t}^{\lambda F}$. Note that A_{t-1} is used to proxy all other factors from above - H_t^{INF} , H_t^{CLUS} , H_t^{LINK} , A_t^ϕ and $H_{A,t}^\lambda$. It should also be observed that under the model described above (the Porter and Stern version), the number of international graduate students is supposed to be implicitly incorporated into the labor and capital resources devoted to the ideas sector – $H_{A,t}^\lambda$. Here it is separated as the goal is to evaluate its individual impact.

Before the model outlined above could be estimated econometrically, it must be accounted for the time difference

between the variables in the model. New ideas production will be measured by total patent applications as a percentage of the labor force. Since there is a lag of five years between the usage of the inputs in the idea production function and the application for a patent, the number of international graduate students will have a five year lag with respect to patent applications (Popp et al. 2004). Furthermore, the number of international graduate students is taken as a proportion of the total number of graduate students in order to account for any changes in the overall size of the graduate programs. In its general form the econometric model used looks like:

$$PALF_t = \alpha + \lambda F * IGTG_t + \alpha_1 * PALF_{t-1} + \epsilon_t$$

The dependent variable, patenting activity, is the most commonly used proxy in innovation studies (Trajtenberg, 1990). Patents are a reasonable proxy for innovation, because they reflect novelty and economic value

as exhibited by the fact that it is hard and expensive to obtain a patent. Using the lagged dependent variable as a regressor is not too unreasonable. As explained above there are many independent variables that are hard to capture directly and in this way it can be at least partially accounted for them. Furthermore, previous inventions help the creation of current inventions and therefore should be included in the model (Porter and Stern, 2000). Also, previous innovative activity is a manifestation of past inputs, which accumulate over time to determine current innovation.

Because this is a time –series estimation, the stationarity of the variables must be taken into account. Two econometric specifications are estimated – one in which a time trend is incorporated to observe the short-term relationship between the variables and one in which no time trend is included with the goal of capturing the variables’ long term equilibrium relationship. The last could be

performed because the two variables of interest – patent applications and international graduate students – are cointegrated. They share similar stochastic trends. The resulting econometric specifications are as follows:

$$PALF_t = \alpha + \lambda F * IGTG_t + \alpha_1 * PALF_{t-1} + \varepsilon_t$$

$$PALF_t = \beta + \lambda F_1 * IGTG_t + \beta_1 * PALF_{t-1} + \theta_1 * t + \varepsilon_t.$$

As already deliberated, the impact of international students on innovation has been differently evaluated using different methodologies. Levin and Stephan estimate that foreign-born scientists play a disproportionate role in generating knowledge in the USA (1999). This is confirmed by the assertion that a 10% increase in the number of foreign graduate students would raise patent applications by 5% (Chellaraj, 2008). However, as mentioned before, there are some studies saying that foreign students crowd out native white students from graduate programs, where the effect is biggest in the most elite institutions (Borjas, 2005).

Using the two economic specifications above the aim is to evaluate what the impact of international graduate students is. That depends on the signs of the coefficients λF and λF_1 . While the coefficient in the long-term equilibrium relationship, λF , is expected to have a positive sign, the one in the de-trended version, λF_1 , could have either a positive or a negative value. This is because the short-term impact of international graduate students is not so clear – there might be a short term crowding-out effect that is later eliminated as graduate programs expand (Freeman, 2005). Such a crowd-out effect may mean that an increase in the number of foreign graduate students does not contribute to innovation at least in the short run.

IV. DATA

As already explained, patenting activity, is the most commonly used proxy in innovation studies (Trajtenberg, 1990). There are two important reasons suggesting that

patents are indeed a reasonable proxy for innovation. First, to be awarded a patent, a certain invention must be novel, meaning that patents indeed capture new ideas. Second, it is quite costly to apply for a patent – this suggests that the patenting entity must believe that there is some economic value associated to its patent. There are many pitfalls in using patenting activity as a proxy for innovation – not all inventions are patentable, not all inventions are patented and the inventions that are patented differ significantly in value (Griliches, 1984). Nevertheless, patenting activity is the best available measure (Trajtenberg, 1990). Data on patents awarded to different institutions was gathered from the website of the US Patent and Trademark Office.

Another measurement limitation is reflected in the variable IGTG. In the model employed here IGTG is the fraction of international graduate students to total graduate students. The innovation literature (Porter and Stern, 2001)

says that the resources devoted to R&D sector are an important input in the innovation function. That would mean that only the part of international graduate students that specializes in the sciences should be included. However, such data is unavailable. Consequently, the total number of international graduate students is used. This is not an over-restrictive assumption, as the number of international graduate students in the sciences and engineering is about eighty percent. Figures on international graduate students were obtained from *Open Doors*, the publication of Institute for International Education.

The two economic specifications outlined above are estimated over the period 1969 - 2003. Below is a table with the basic statistical properties of the variables:

Variable	Obs	Mean	St. Dev.	Min	Max
IGTG	37	8.411081	2.164665	4.61	11.97
L.PALF	35	1.565074	0.648049	0.936836	2.981165
PALF	35	1.565074	0.648049	0.936836	2.981165

V. EVIDENCE

A. The Long Term Equilibrium Specification

Estimating the first specification resulted in a model that had the following coefficients and significance of the variables:

Long Term Equilibrium Specification			
	Coefficient	t-statistic	P-value
IGTG	0.0223345	2	0.054
L.PALF	0.9962844	25.53	0.000
_cons	-0.123392	-2.26	0.031
Adj R-squared = 0.9876			

The model did not pass the Breusch-Pagan test for heteroskedasticity. The null hypothesis that the variance of the error terms is constant was rejected, because the P-value of the chi-square statistic equaled 0.0446, which is rejected at the 5 % level of significance. After correcting for the problem of heteroskedasticity, the following values were obtained from the regression with robust standard errors for the coefficients and the significance P of the variables:

Long Term Equilibrium Specification			
Variable	Coefficient	t-statistic	P-value
IGTG	0.0223345	1.94	0.062
L.PALF	0.9962844	21.68	0.000
_cons	-0.123392	-3.26	0.003
Adj R-squared = 0.9884			

It was also found that the model is the appropriate functional form as it passes the Ramsey's test. The null-hypothesis that there are no omitted variables is failed to be rejected, as the P-value of the F-statistic equals 0.4048. It is also ascertained that the model does not suffer from autocorrelation. The Durbin-Watson test has a statistic of 1.841373, which in a model with three estimated parameters and 33 observations is in the acceptable region. Multicollinearity was also not observed – the mean VIF was 3.44. Moreover, the model seems accurate as the coefficient of the L.PALF is positive and very significant – it has a P-value of 0.000, which means that the null-hypothesis that the coefficient is equal to zero is rejected. This is just as expected. Also, it should be noted that the adjusted R-

squared is very high – 0.9884, suggesting that the model is a good fit. The test for overall significance of the model is confirming that the independent variables are jointly significant. The F-statistic is very high - 1283.64.

It can be seen that the coefficient of IGTG is positive. As expected, it is less significant than before the correction for heteroskedasticity, but the null hypothesis that it is equal to zero is still rejected at the 10% level of significance. The interpretation of this coefficient is that for every percentage point increase in the ratio of international graduate to total graduate students, the ratio of patent applications to the labor force increases by approximately 0.02 percentage points. This means that in the long-term the presence of international graduate students is exerting a positive impact on US innovation.

B. Specification with De-trended Variables

Estimating the second specification resulted in a model with the following coefficients and significance of variables:

De-trended Version			
Variable	Coefficient	t-statistic	P-value
IGTG	-0.0210377	-0.95	0.35
L.PALF	0.9304208	19.72	0.000
_cons	0.0874489	0.81	0.425
Adj R-squared = 0.9890			

The model did not pass the Breusch-Pagan test for heteroskedasticity. The null hypothesis that the variance of the error terms is constant was rejected, because the P-value of the chi-square statistic equaled 0.0084, which is rejected at the 5 % level of significance. Therefore, it was corrected for the problem of heteroskedasticity and the following values were obtained from the regression with robust standard errors for the coefficients and the significance of the variables:

De-trended Version			
Variable	Coefficient	t-statistic	P-value
IGTG	-0.0210377	-0.86	0.398
L.PALF	0.9304208	20.01	0.000
time	0.013332	2.44	0.021
_cons	0.0874489	0.81	0.425
Adj R-squared = 0.9901			

It was found that the model has the appropriate functional form as it passes the Ramsey's test. The null-hypothesis that there are no omitted variables is not rejected, because the P-value of the F-statistic equals 0.4881. It was also ascertained that the model does not suffer from autocorrelation. The Durbin-Watson test has a statistic of 1.841373, which in a model with four estimated parameters and 33 observations is in the acceptable region. Moreover, the model seems accurate as the coefficient of the L.PALF is positive and very significant – it has a P-value of 0.000, which means that the null-hypothesis that the coefficient is equal to zero is rejected. This is just as expected. Also, it should be noted that the adjusted R-squared is very high –

0.9901, suggesting that the model is a good fit. The test for overall significance of the model is confirming that the independent variables are jointly significant. The F-statistic is very high - 850.23.

This time the coefficient of IGTG is negative. Furthermore, it is not significant as it has a P-value of 0.398. Therefore, the null hypothesis that the coefficient is different from zero is not rejected. This means that as we de-trend the variables, that is, as we capture their short-term relationship, the effect of international graduate students on innovation becomes negative and insignificant.

C. Summary of Results

In summary, as we compare the two econometric specifications we find out that in the long-term the number of international graduate students significantly (at the 10% level) affects innovative activity. However, when the short-

term relationship of the variables is analyzed it is found that the effect of the variable of interest is negative and insignificant. The last could be due to the fact that in the short-run the size of a particular university's student body is fixed and accepting one additional foreign student would mean not accepting a domestic student. The former could be explained by the expansion of graduate programs in the long-run. Such an expansion allows for the accommodation of more international graduate students without the displacement of domestic ones.

In light of the results obtained, it is quite expected that a concentration on the short-term and university-level would lead to the observance of a negative relationship (Borjas, 2005). Furthermore, a concentration on the long-term and national-level would lead to the observance of a positive relationship (Chellaraj, 2008).

VI. CONCLUSIONS

This paper attempted to unify the contradicting studies existing so far in the literature about the contribution of international graduate students to US innovation. It tried to explain why some studies implied a positive relationship between international graduate students and US innovation, while others suggested a negative one.

Two econometric specifications were estimated – one in which a time trend was incorporated to observe the short-term relationship between the variables and one in which no time trend was included with the goal of capturing the variables' long term equilibrium relationship. The results suggested that in the long-term the number of international graduate students significantly (at the 10% level) affects innovative activity. However, when the short-term relationship of the variables was analyzed it was found that the effect of the variable of interest is negative and

insignificant. This was attributed to the fixed size of graduate programs in the short run and their tendency to expand in the long-run.

Further research on the subject could improve the model by adding more variables. In its current version the analysis employs a simplistic auto-regressive form with two variables. Furthermore, more observations could be added as this was a time series model that had only a single observation per year. This could be achieved if a model that implements some form of the ideas production function at the state-level is used.¹¹

As already suggested, the findings of this paper have significant immigration policy implications (Maskus, 2007). First, graduate enrollments at domestic universities in technical fields should be increasingly made more open to foreign students. Second, investment into excellent research

¹¹ Such a model was utilized by Hunt in estimating the impact of high-skilled immigrants on US innovation (2008).

facilities should be made a priority in order to attract the increasingly global pool of science and engineering students. Third, international graduate students in S&E should be placed on an accelerated track to citizenship.

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