Table 1: Data sources

Variable	1st Period	2nd Period	Source
Per capita capital stock growth	1975-1990	1990-2004	Penn World Table
Per capita capital stock	1985-1990 mean	1999-2004 mean	Penn World Table
Disaggregated tariffs	1985-1993	2000-2004	Estevadeordal and Taylor
Disaggregated wages	1985-1991 mean	1999-2008 mean	Occupational Wages of the World
Aggregated 1985 tariffs			Estevadeordal and Taylor
Great Depression depth			Estevadeordal and Taylor

__Data__

We used data from three sources: the Penn World Table, Estevadeordal & Taylor (2013), and Occupational Wages of the World. Table #<> summarizes the variables and their sources. Our sample size is limited by the coverage of the tariff data in Estevadeordal & Taylor and the wage data in Occupational Wages of the World.

We measured the rate of capital stock accumulation as the geometric growth between 1975 and 1990 for the first period and 1990 and 2004 for the second. This corresponds to the GDP growth period that Estevadeordal & Taylor (2013) use to estimate the effect of capital tariffs on GDP growth. For measuring capital stock levels, we take the average of two six-year periods to mitigate the impact of business cycles on the data.

Wages in supervisory and technical occupations were defined as "high skill", while everyone else, such as production line workers, were defined as "low skill". This is in accordance with Zhu & Trefler <year>. Only workers in the manufacturing sector were included. Since we did not have measurements of the number of workers in each occupation, we computed the simple average of all occupations in each skill category. Ideally, the periods of time for measurement of capital stock and wages would be the same, but missing occupational wage data was a serious problem. Therefore, we somewhat extended the period of time of measuring wage data to avoid dropping too many countries from the sample.

Estevadeordal & Taylor recorded three different tariff measures: consumption goods, intermediate goods, and capital goods. They could not obtain disaggregated tariff data for the same years in each country, so the measured tariff rates are spread over a number of years. In their main regression specification, Estevadeordal & Taylor used the simple average of intermediate and capital goods tariffs to explain GDP growth. Therefore, we will use this average and call it capital goods tariff for the remainder of this paper.

The number of countries available in the tariff dataset is limited, but there is no obvious reason that selection bias may be a factor in our analysis.

Summary statistics of the variables, after transformation and taking first differences, are available in Tables #<> and #<>. We use the World Bank's classification of developing country as of the 1980's.

Table 2: Summary statistics of developing countries

	Mean	Std. dev	Min	Max
%Δ of per capita K	-0.002	0.021	-0.043	0.040
$\ln(1+\tau_K/100)$	-0.155	0.121	-0.447	0.040
$\ln(1+\tau_C/100)$	-0.205	0.206	-0.719	0.122
$\ln(1+\tau_K/100)\times\ln(1+\tau_C/100)$	-0.109	0.132	-0.550	0.018
$\ln(w_H/w_L)$	0.007	0.279	-0.640	0.437
ln(Per capita K stock)	0.296	0.376	-0.447	1.263

Table 3: Summary statistics of developed countries

	Mean	Std. dev	Min	Max
%Δ of per capita K	-0.009	0.008	-0.028	0.010
$\ln(1+\tau_K/100)$	-0.037	0.040	-0.193	0
$\ln(1+\tau_C/100)$	-0.052	0.056	-0.247	0.017
$\ln(1+\tau_K/100)\times\ln(1+\tau_C/100)$	-0.008	0.014	-0.063	0.0001
$\ln(w_H/w_L)$	0.041	0.151	-0.284	0.404
ln(Per capita K stock)	0.320	0.141	0.129	0.670

___Endogeneity in the Wage-Capital equation____

We should be concerned about simultaneous causation in equation #<>. Modeling only one side of the supply-demand relationship is a well-known pitfall in econometrics. However, the relationship between capital stock and the wage premium is indirect: it operates through the complementarity of capital and high-skilled labor. Therefore, it is not appropriate to model the relationship as a full supply-demand simultanous equation system.

We will still take an instrumental variable approach. A straightforward instrument for the level of capital stock is r, the price of capital accumulation. In a closed economy, r is determined endogenously; firms'

solutions to their profit maximization problems should ensure that $r = {}^{\partial F}/_{\partial K}$, where $F(\cdot)$ represents the aggregate production function. In an open economy, r can be determined exogenously. The import price of capital goods determines the domestic capital price in the Atolia model. Clearly we want to avoid assuming aspects to the Atolia model while we test it, however. We can rely on other models in which international financial markets can exogenously determine r<citation?>. Thus, r is determined in other countries rather than endogenously. In principle, this could lead to all countries facing the same r, which would present a statistical identification problem. We observe that r is not equalized across countries, though, so we can proceed <make citation of a paper dealing with this. Also, this challenges a bit our assertion that r is exogenously determined>.

According to the firm's optimization problem, if an exogenous shock to r leads to ${}^{\partial F}/_{\partial K} < r$, then capital should be accumulated faster. If ${}^{\partial F}/_{\partial K} > r$, then the capital stock should shrink. This leads to the following functional relationship: ${}^{\partial K}/_{\partial t} = G(r)$, i.e. the change of K over time is a function of r. Our RHS variable in equation #<> is in levels of K, not change, so we must integrate both sides with respect to time: $K = \int_a^b G(r)\, dt$. If $G(r)$ is simply linear, then we can approximate this relationship by simply summing over the value of r in each time period: $K = \sum_{t=a}^{b} r_t + \epsilon$. For an IV strategy, we need the assumption that r affects the wage premium only through its effect on capital accumulation. <TODO: justify a little>. The first stage of the model can then be expressed as

$\triangle \ln K_{it} = \alpha'' + \beta_r \triangle \ln \left(\sum_{t=a}^{b} r_t \right) + \triangle \xi_{it}$

and the second stage is just the original equation that we wanted to estimate:

$\triangle \ln \dfrac{w_{H\,it}}{w_{L\,it}} = \alpha' + \beta_K \triangle \ln K_{it} + \triangle v_{it}$

An estimate of r for each country and year is available from the Penn World Table. We will divide the price of investment by the price of consumption to obtain the real investment price. We choose the years 1975-1990 for the first period measurement of $\sum_{t=a}^{b} r_t$ and 1991-2004 for the second period, which matches the periods of measurement for capital stock growth in the tariff-capital equation.

The fatal flaw in the approach outlined above is that r turns out to be an extremely weak instrument for capital accumulation. The F-statistic for a regression of $\triangle \ln K_{it}$ on $\triangle \ln \left(\sum_{t=a}^{b} r_t \right)$ is 0.20. In light of the rule of thumb that an instrument is weak if the F-stat is less than ten, this instrument appears to be useless. <Staiger and Stock (1997) http://www.econ.brown.edu/fac/Frank_Kleibergen/ec266/staigerstock1997.pdf> Therefore, we have to discard this approach. If we cannot detect an effect of the price of investment on capital accumulation, then it seems no other variable would be powerful enough to act as a strong instrument, so here we abandon our efforts to handle endogeneity in the wage-capital equation. As consolation, the

weakness of r as an instrument for capital accumulation provides indirect evidence that the effect of the wage premium upon capital accumulation may be weak. That is to say, if the price of capital accumulation itself does not detectably affect capital accumulation, the price of another factor of production probably does not affect it either. Hence, the problem of endogeneity that spurred this exercise may not be worrisome. In any case, the results

___Results__

<say that throughout, our precision is limited by sample size>

Among developing countries, the correlation between changes in capital and consumption tariffs is 0.89. Thus, regressing capital accumulation against both variables (and their product) would inflate the variance of the estimated coefficients. Any effect may be masked by this variance inflation. Therefore, we will start by presenting a parsimonous specification that only includes the product of the two tariffs, which is our main coefficient of interest. Table 1 displays these results.

Given that many coefficients are not different from zero, the table shows t-statistics rather than standard errors so it is easier to assess the distance from statistical significance. Among developing countries, we detect no effect of the capital and consumption tariff cross term on the rate of capital accumulation, although the sign of the point estimate is consistent with the theory. The level of capital stock, however, does have an effect on the wage premium that is different from zero at the 5% level. We have estimated that a one percent rise in the per capita capital stock leads to a 0.3% rise in the ratio of high-skill wages to low-skill wages.

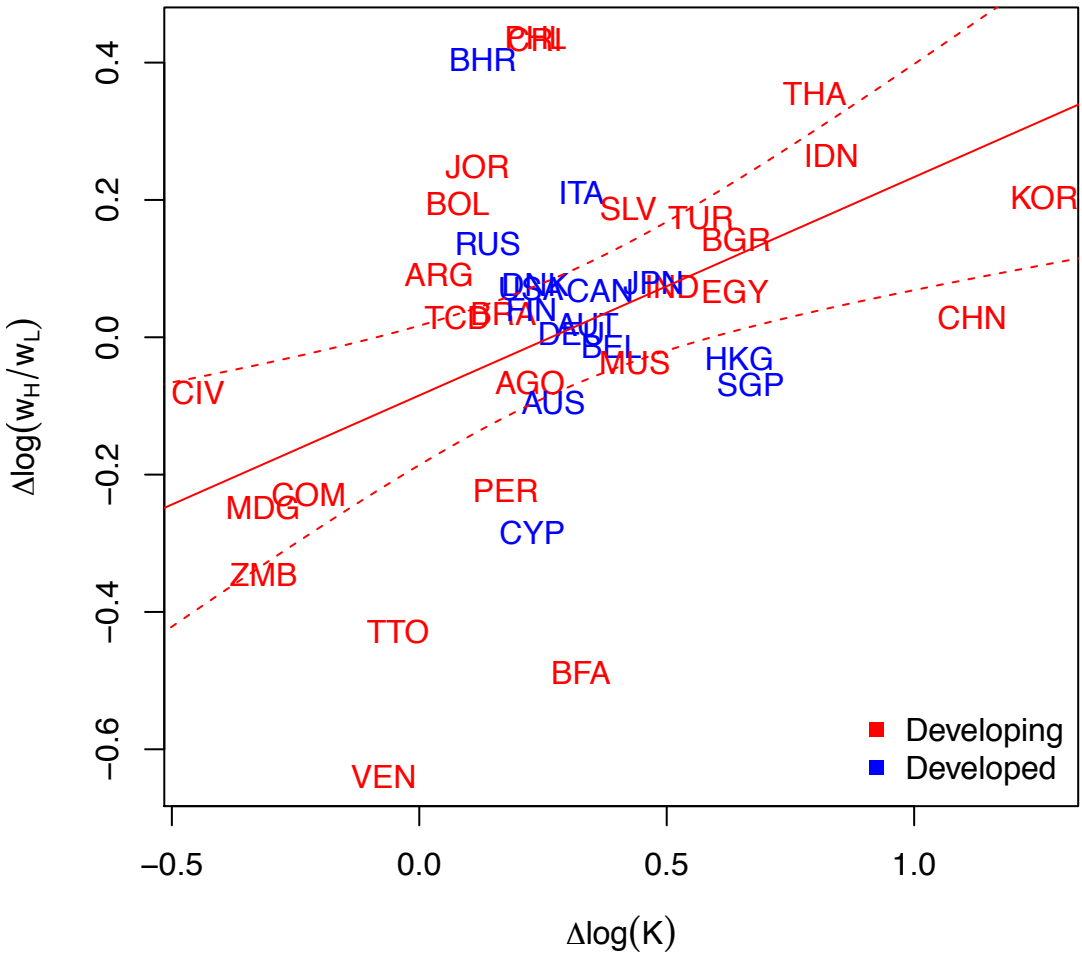
We also include an estimation of the same model with both developed and developing countries. Interaction terms separate the effects on the two groups. For the Atolia theory to be true, we need the effect to exist for developing countries, but not for developed countries. The results are consistent with the theory. The effect of the product of capital and consumption tariffs for developing countries is not statistically different from zero, but the estimated sign is negative, consistent with theory. Furthermore, the point estimate for developed countries is positive but not statistically significant. If these effects were statistically significant, we might conclude that the Atolia mechanism holds for developing countries but not developed countries. Finally, the results suggest that the positive effect of capital stock on the wage premium holds only for developing countries. This result is visualized in Figure 1.

Table 4: First difference SUR without instrument on first equation
(t-statistics in parentheses)

	Sample			
	Developing countries		World	
	Dependent variable			
	1st eqn $\%\Delta$ of per capita K	2nd eqn $\ln(w_H/w_L)$	1st eqn $\%\Delta$ of per capita K	2nd eqn $\ln(w_H/w_L)$
(Intercept)	−0.008	−0.085	−0.006	0.144
	(−1.511)	(−1.324)	(−1.389)	(1.127)
$\ln(1+\tau_K/100)\times\ln(1+\tau_C/100)$	−0.042		0.306	
	(−1.414)		(1.115)	
ln(Per capita K stock)		0.318**		−0.311
		(2.536)		(−0.890)
Developing country			−0.002	−0.229
			(−0.303)	(−1.665)
$\ln(1+\tau_K/100)\times\ln(1+\tau_C/100)\times$ Dev cntry			−0.348	
			(−1.264)	
ln(Per capita K stock)× Developing country				0.629*
				(1.733)
R^2	0.081	0.238	0.123	0.224
Adj. R^2	0.045	0.207	0.060	0.161
Num. obs.	27	26	46	41
Residual ρ between equations		0.096		0.060

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Figure 1: Capital accumulation raises wage premium for developing countries



When the tariff level is instrumented by GATT membership × 1985 average tariff, the results for the developing country sample, shown in Table <>, are basically unchanged. On the other hand, the signs of the coefficients on the capital-tariff eqution for the world sample are the opposite of what they were in the uninstrumented regression. If these coefficients were statistically significant, it would challenge the theory that lower capital tariffs increase the capital stock for developing countries but not developed. However, the very low precision of the estimates here (t-stats around 0.4) means that we cannot conclude that any violation of the Atolia theory really exists. A Wu-Hausman test cannot reject the null hypothesis of no endogeneity, but the test is expected to have low power in this environment of a small number of observations.

For completeness, we also present the results with the "saturated" model of capital tariffs, consumption

Table 5: First difference 3SLS with GATT membership × 1985 average tariff as instrument on first equation (t-statistics in parentheses)

	Sample			
	Developing countries		World	
	Dependent variable			
	1st eqn $\%\Delta$ of per capita K	2nd eqn $\ln(w_H/w_L)$	1st eqn $\%\Delta$ of per capita K	2nd eqn $\ln(w_H/w_L)$
(Intercept)	−0.009	−0.085	−0.022	0.144
	(−1.608)	(−1.324)	(−0.745)	(1.127)
$\ln(1+\tau_K/100) \times \ln(1+\tau_C/100)$	−0.059		−1.845	
	(−1.431)		(−0.484)	
ln(Per capita K stock)		0.318**		−0.311
		(2.536)		(−0.890)
Developing country			0.013	−0.229
			(0.409)	(−1.665)
$\ln(1+\tau_K/100) \times \ln(1+\tau_C/100)\times$ Dev cntry			1.786	
			(0.469)	
ln(Per capita K stock)× Developing country				0.629*
				(1.733)
R^2	0.068	0.238	−1.244	0.224
Adj. R^2	0.031	0.207	−1.404	0.161
Num. obs.	27	26	46	41
F-stat on first stage	25.530		55.866	
P-value of Wu-Hausman endogeneity test	0.557		0.411	
Residual ρ between equations		0.118		−0.011

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

tariffs, and their product in Table #<>. As expected, the high correlation between the two tariffs greatly inflates the variance of the coefficients. The point estimates are consistent with the Atolia theory, however, since the sign of the capital tariff coefficient is negative while the sign of the consumption tariff is positive. We also estimated a three-stage least squares model. To instrument for the consumption tariff, we used the severity of the Great Depression × 1985 average tariff as Estevadoreal & Taylor did, but the variance of the coefficients is so large that the results are not worth presenting.

___ DRawbacks__

___Conclusion/discussion___

In light of our empirical test, we cannot reject the Atolia theory. The positive effect of capital accumulation on the wage premium among developing countries offers limited support for the theory. In some sense, this effect is the less important part of the theory since it could, arguably, be unrelated to trade. Throughout, our analysis suffers from low statistical power <><> <elasicity>

<TODO: Look at schooling - like the supply of high skilled labor>

<in our data table, can say that a var coresponds to something in the PWT>

<Should say something about having dif #'s of obseravtions in the two SUR equations>

Table 6: First difference saturated SUR without instrument on first equation (t-statistics in parentheses)

	Sample			
	Developing countries		World	
	Dependent variable			
	1st eqn $\%\Delta$ of per capita K	2nd eqn $\ln(w_H/w_L)$	1st eqn $\%\Delta$ of per capita K	2nd eqn $\ln(w_H/w_L)$
(Intercept)	−0.007	−0.085	−0.005	0.144
	(−0.943)	(−1.324)	(−0.585)	(1.127)
$\ln(1+\tau_K/100) \times \ln(1+\tau_C/100)$	−0.066		0.196	
	(−0.665)		(0.129)	
$\ln(1+\tau_K/100)$	−0.016		0.108	
	(−0.184)		(0.174)	
$\ln(1+\tau_C/100)$	0.026		−0.053	
	(0.450)		(−0.198)	
ln(Per capita K stock)		0.318**		−0.311
		(2.536)		(−0.890)
Developing country			−0.002	−0.229
			(−0.181)	(−1.665)
$\ln(1+\tau_K/100) \times \ln(1+\tau_C/100)\times$ Dev cntry			−0.262	
			(−0.172)	
$\ln(1+\tau_K/100)\times$ Developing country			−0.124	
			(−0.199)	
$\ln(1+\tau_C/100)\times$ Developing country			0.079	
			(0.291)	
ln(Per capita K stock)× Developing country				0.629*
				(1.733)
R^2	0.092	0.238	0.133	0.224
Adj. R^2	−0.027	0.207	−0.027	0.161
Num. obs.	27	26	46	41
Residual ρ between equations		0.049		0.020

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$