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Term Paper

Difference in Differences Analysis of Trade Liberalization and Per Capita Income Convergence

Submitted by

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Introduction

The hypothesis that trade converges income was believed to be true when tested through single comparison (single difference studies) methodology on two groups of countries; in this paper, we will explore how the difference-in-difference approach solves the potential ambiguities in the previous approach and analyze whether liberalization of trade effects the convergence of income in the countries or not.

Research Gap

The evidence from studies (Sachs and Warner and Ben-David) on trade and international income differences is mixed. There is some evidence that trade causes divergence and other evidence that it causes convergence. Moreover, the evidence on convergence may need to be clarified due to the research design. These studies identify the effects of trade mainly through a single comparison (at most) of two groups of countries. This use of just a single difference leaves the evidence somewhat open to interpretation. In what follows, we aim to build on these studies by identifying trade liberalization's effect on convergence using a difference-in-differences estimation strategy.

Literature Review

Trade liberalization and per capita income convergence: a difference-in-differences analysis - MJ Slaughter (2001)

The paper discusses the theoretical background, where trade theory itself does not provide a clear expected outcome regarding the effects of liberalization on income convergence or divergence. It scrutinizes empirical evidence, which presents mixed results: some studies suggest that trade causes income divergence, while others find evidence of convergence. Fundamental studies highlighted include Bernard and Jones (1996), who observed income divergence in manufacturing sectors and convergence in services sectors post-1970, and Ben-David (1993, 1996) as well as Sachs and Warner (1995), who linked trade to income convergence among countries that were relatively open to each other, had liberalized trade, or traded extensively with each other.

Convergence across States and Regions, Barro and Sala-i-Martin, 1991

The paper provides empirical evidence for convergence of per capita income and GDP in US states and eastern European regions, and forecasts on western European regions predicting slow growth rates. It uses the neoclassical growth model: $(1/T) \cdot \log(yit/yi,t\text{-}T)=xi^*+\log(\hat{y}i^*/\hat{y}i,t\text{-}T) \cdot (1\text{-}e\text{-}\beta T)/T+u_{it}$,

Where β is rate of conditional convergence and indicates rate at which $\hat{y}_{it}$ approaches $\hat{y}_i^*$.

β-convergence tells how fast and to what extent per capita income of one economy catches up with average per capita income across economies. σ-convergence tells how distribution of per capita income across economies has behaved in the past and is likely to behave in future.

The model used for a closed economy, can not be applied to the US economy. In an open economy with the same technologies, convergence occurs more rapidly in open than closed economies, but convergence in per capita income and assets occurs less rapidly. The paper looks at the converging/diverging effect of more mobility in labour, capital, technological advancements across economies.

Increasing Returns and Long-Run Growth, Paul Romer 1986

The paper gives a long-run growth model on the assumption that knowledge is an input in production with increasing marginal productivity. It uses a competitive equilibrium model with endogenous technological change. In contrast to models on diminishing returns assumption, growth rates can be increasing over time and large countries may always grow faster than small countries. Moreover the level of per capita income need not converge. There is slow or no growth in less developed countries. The paper points to growth divergence by providing long-run empirical evidence. A substantial contribution of the paper was to build a model in which the long-run growth rate was determined endogenously, and to highlight that, because of externalities, the equilibrium growth rate might be lower than is optimal.

Endogenous Technological Change, Paul Romer 1990

In this paper Romer developed endogenous growth theory and was awarded the Nobel Prize.

His model is similar to the Solow growth model but with added technology aspect. He emphasizes endogenous technological change and its fixed cost nature. This is famously referred to as nonrivalry of ideas giving rise to increasing returns. The paper draws conclusions that stock of human capital determines growth rate and that integration into world markets (free markets) will increase growth rates. It points out that too little human capital takes up research in an equilibrium state and that having a large population is not sufficient to generate growth.

On the Mechanics of Economic Development, Robert Lucas 1988

The paper extends the Solowian neoclassical growth model and produces three models by emphasizing on physical capital accumulation and technological change, human capital accumulation through schooling and specialized human capital accumulation through learning-by-doing, in each model.

Chad Jones's work on Growth Theory

In "The End of Economic Growth? Unintended Consequences of a Declining Population," potential ramifications of declining fertility rates are considered, which suggested that a shrinking population could lead to stagnation of economic growth. In another contribution, "Artificial Intelligence and Economic Growth," the impact of AI on economic growth is studied by looking at explosive growth driven by AI advancements and steady automation.

The existing evidence on trade and international income differences is mixed. Some evidence suggests trade causes divergence while other evidence suggests it causes convergence. Bernard and Jones (1996) provide evidence that freer trade diverges income across countries.

In contrast with these results, Ben-David (1993, 1996) and Sachs and Warner (1995) present evidence linking trade to income convergence by identifying trade's effect through a single comparison of two groups of countries. Sachs and Warner conclude that open economies display a strong tendency towards economic convergence. Ben-David (1996) found that groups of relatively wealthy countries which traded well among each other displayed significant per capita income convergence compared to convergence patterns in randomly grouped countries.

Objective

1. To determine differences in rates of per capita income convergence pre- vs. post-liberalization for liberalizing countries.
2. To determine difference in differences in rates of per capita income convergence pre- vs. post-liberalization; liberalizing vs. control countries (the EEC case, the EFTA case, the EEC-EFTA case)

Data Source

All data comes from the Penn World Tables of Summers and Heston (2019). Both real income per capita and per worker are in this data set. We use income per worker because most convergence models assume all people work. Because there is a very high sample correlation between labor forces and populations.

Methodology

The outcome of interest is some measure of per capita income dispersion. We first measure the log per capita income standard deviation among a group of countries. This dispersion measure is given by

$$\sigma_{rt} = \alpha_1 + \alpha_2(d_r) + \beta_1(t) + \beta_2(t)(d_r) + e_{rt} \text{......(1)}$$

where t indexes time in years running from t = 1 until t = T: r indexes the two equal-length regimes of interest: r = 0 for the post-liberalization regime running from t = (1 + T/2) until t = T; d_r is a dichotomous variable equal to one if r = 1 and zero if r = 0, and e_rt is an error term. The regressand sigma_rt is the standard deviation of natural log of income per capita. Single difference β2 indicates whether post-liberalization convergence differs from that of pre-liberalization.

For the **difference-in-differences specification**, let the superscript j indicate the country group, with j = 1 the liberalizing group and j = 0 some control group.

$$\sigma^j_{rt} = \alpha_1 + \alpha_2(d_r) + \alpha_3(d^j) + \alpha_4(d^j_r) + \beta_1(t) + \beta_2(t)(d_r) + \beta_3(d^j) + \beta_4(d^j_r) + e_{rt}$$

Where the dichotomous variable d^j indicates country group; and e is an error term. The effect of trade liberalization on income convergence can be obtained by calculating the difference in differences of the estimated rates, equal to β4 here.

The **second measure** of income dispersion captures how quickly each country's income level is converging to the average income level of that country's group.

$$(y_{it+1} - y^-_{t+1}) = \gamma(y_{it} - y^-_t)$$

Where y_it is the country, I'm logging real income per worker in year t, y bar_t is the arithmetic average of y_it, and gamma is a parameter relating the average income gap from one year to the next. Then define

$$z_{it} = (y_{it} - \bar{y_t})$$

For initial single difference analysis:

$$\Delta z_{rit+1} = \delta_1(z_{rit}) + \delta_2(z_{rit})(d_r) + u_{rit}$$

The single difference δ2 indicates whether post-liberalization convergence differs from that of pre-liberalization.

For **difference in difference** analysis:

$$\Delta z^j_{rit+1} = \delta_1(z^j_{rit}) + \delta_2(z^j_{rit})(d_r) + \delta_3(z^j_{rit})(d^j) + \delta_4(z^j_{rit})(d^j_r) + u^j_{rit}.$$

The trade liberalization effect on income convergence can be obtained by calculating the difference in differences of the estimated rates, equal to δ_4 here.

Hypotheses

1) Null hypothesis (H0) - β2 is significant in the first difference equation of log per capita income standard deviation. (positive would signify convergence)
   Alternate Hypotheses (H1) - the coefficient is not significant
2) Null hypothesis (H0) - β4 is significant in the DID equation of log per capita income standard deviation.
   Alternate Hypotheses (H1) - the coefficient is not significant
3) Null hypothesis (H0) - δ2 is significant in the single difference equation of z
   Alternate Hypotheses (H1) - δ2 is not significant
4) Null hypothesis (H0) - δ4 is significant in the DID final equation of z (positive hence signifying convergence)
   Alternate Hypotheses (H1) - coefficient of convergence is not significant hence signifying no convergence of the countries.

Results and Conclusions

Preliminary analysis: σ_t plots against time

We plot the sigma measure (σ_t) of income dispersion for each trade liberalization. If there has been a convergence of incomes, we would expect σ_t, the dispersion of incomes, to decrease over the years as countries move towards the same income level. Thus a downward trend in σ_t with time would point to a convergence of income levels in the country. Similarly an upward trend would suggest a divergence of income levels in the country while a flat trend would suggest neither convergence nor divergence. We find **downward trends for EEC and EFTA** but an **upward trend for Kennedy round**. Thus we find convergence in EEC and EFTA groups of countries but divergence in Kennedy round countries.

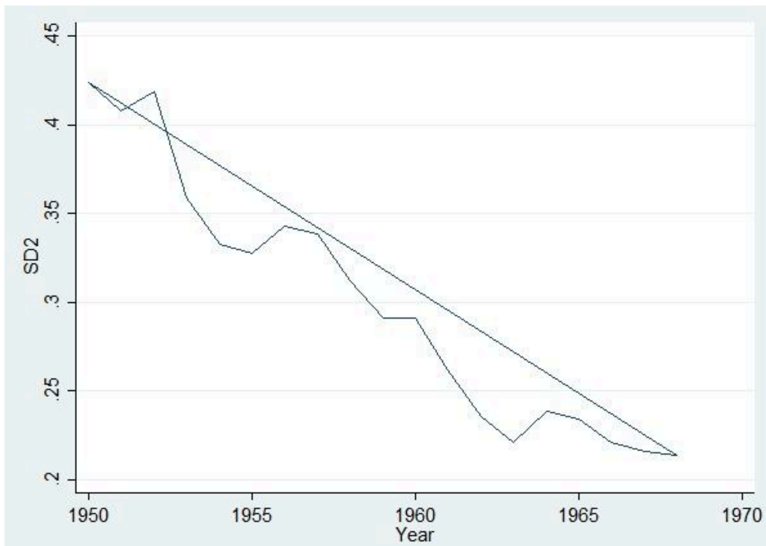

Fig1: EEC downward trend suggests convergence (-45^{O} line plotted for comparison, the plot lies below it)

Fig 2: EFTA downward trend suggest convergence

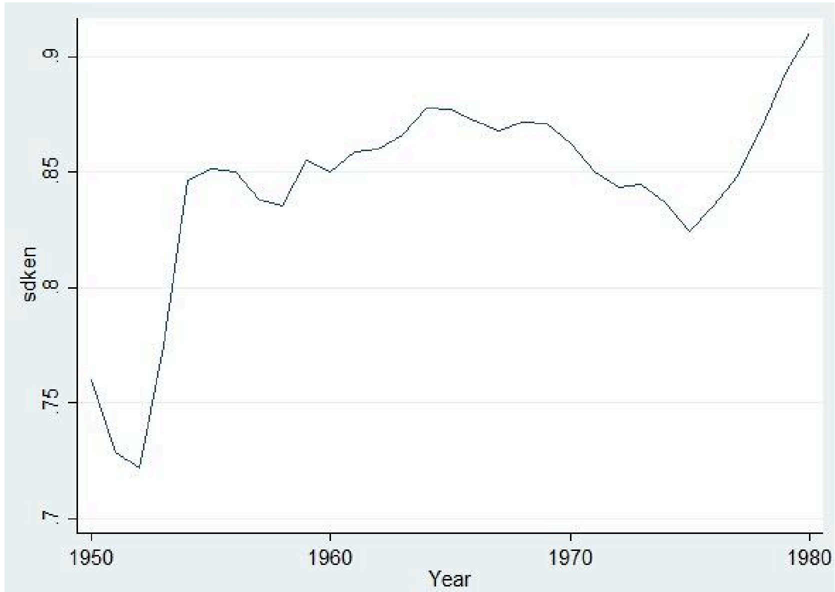

Fig 3: Kennedy Round upward trend suggests divergence

Difference in Difference Results
The following table summarizes the results from the difference-in-differences estimates using the sigma and delta-z measure of dispersion. The results of interest are β_4 and δ_4 respectively. They give the effect of trade liberalization on convergence in these country groups after excluding possible external factors' effects on convergence (by controlling for external effects using a control group of countries in difference-in-differences method).

Positive β_4 and δ_4 suggest convergence in income levels while negative values suggest divergence. We see that EEC has contributed to the convergence of income levels in the member countries as both β_4 and δ_4 are positive. We find similar convergence in combined EEC and EFTA groups. But for EFTA and Kennedy Round, we see both positive and negative coefficient values. Convergence is suggested by one measure while divergence is suggested by the other. Compared with the previous single difference estimates, we see a reduced converging effect of trade liberalization, as expected after controlling for external effects in DID method.
We conclude that EEC has seen a definite positive effect on convergence in the member countries, but the results remain ambiguous for EFTA and Kennedy Round, considering the contrasting plots, single difference and DID results. Thus we have ambiguous results on the overall contribution of trade liberalization on convergence on income levels in member countries. While there are cases where we see definite converging effects, we also find diverging effects in others.

Trade Liberalization	**β_4**	**δ_4**
EEC	**0.0017846(2.05)**	**0.0086325(0.12)**

EFTA	**-0.0064311(-5.96)**	**0.0044701(0.13)**
EEC & EFTA	**0.0130951(20.30)**	**0.0105027(0.46)**
Kennedy Round	**0.0242371(15.85)**	**-0.0000773(-0.01)**

Table 1: Summarized DID results (See Appendix for full results.)

Suggested Improvements

Control group selection can be employed for robustness of analysis. Countries similar to treatment group countries can be included in the control group and dissimilar ones can be excluded. Factors like geography, country income and trade openness can be used as criteria for selecting more similar countries and excluding dissimilar countries.

Later minor liberalisations in countries in control groups can also be accounted for so as to not violate the parallel trends assumptions.

We have looked at major trade liberalisations from the period of 1950s to 1980s. The exercise can be applied to more recent trade liberalisations to better study the effect of trade liberalization on income convergence in recent times.

References

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Appendix

EEC

Sigma

```
egen SD_eec=sd(lnpci), by (year eec)
gen eec_times_eec_per=eec*eec_per
gen year_times_eec_per=year*eec_per
gen year_times_eec=year*eec
gen year_times_eec_times_eec_per=year*eec*eec_per
reg SD_eec eec_per eec eec_times_eec_per year year_times_eec_per year_times_eec
year_times_eec_times_eec_per
```

Delta Z

```
gen y=lnpci
egen y_bar_t_eec = mean(y), by (year eec)
gen z_eec=y-y_bar_t_eec
sort country year
by country: gen lead1_z_eec=z_eec[_n+1]
gen del_z_eec=lead1_z_eec-z_eec
gen z_times_eec_per = z_eec*eec_per
gen z_times_eec = z_eec*eec
```

```
gen z_times_eec_per_times_eec=z_eec*eec_per*eec
reg del_z_eec z_eec z_times_eec_per z_times_eec z_times_eec_per_times_eec, noconstant
```

EFTA

Sigma

```
egen SD_efta=sd(lnpci), by (year efta)
gen efta_times_efta_per=efta*efta_per
gen year_times_efta_per=year*efta_per
gen year_times_efta=year*efta
gen year_times_efta_times_efta_per=year*efta*efta_per
reg SD_efta efta_per efta efta_times_efta_per year year_times_efta_per year_times_efta
year_times_efta_times_efta_per
```

Delta Z

```
gen y=lnpci
egen y_bar_t_efta = mean(y), by (year efta)
gen z_efta=y-y_bar_t_efta
sort country year
by country: gen lead1_z_efta=z_efta[_n+1]
gen del_z_efta=lead1_z_efta-z_efta
gen z_times_efta_per = z_efta*efta_per
gen z_times_efta = z_efta*efta
gen z_times_efta_per_times_efta=z_efta*efta_per*efta
reg del_z_efta z_efta z_times_efta_per z_times_efta z_times_efta_per_times_efta, noconstant
```

EEC & EFTA

Sigma

```
egen SD_eec_efta=sd(lnpci), by (year eec_efta)
gen eec_efta_times_eec_efta_per=eec_efta*eec_efta_per
gen year_times_eec_efta_per=year*eec_efta_per
gen year_times_eec_efta=year*eec_efta
gen year_x_eec_efta_x_eec_efta_per=year*eec_efta*eec_efta_per
reg SD_eec_efta eec_efta_per eec_efta eec_efta_times_eec_efta_per year
year_times_eec_efta_per year_times_eec_efta year_x_eec_efta_x_eec_efta_per
```

Delta Z

```
gen y=lnpci
egen y_bar_t_eec_efta = mean(y), by (year eec_efta)
gen z_eec_efta=y-y_bar_t_eec_efta
sort country year
by country: gen lead1_z_eec_efta=z_eec_efta[_n+1]
gen del_z_eec_efta=lead1_z_eec_efta-z_eec_efta
gen z_times_eec_efta_per = z_eec_efta*eec_efta_per
gen z_times_eec_efta = z_eec_efta*eec_efta
gen z_x_eec_efta_per_x_eec_efta=z_eec_efta*eec_efta_per*eec_efta
reg del_z_eec_efta z_eec_efta z_times_eec_efta_per z_times_eec_efta
z_x_eec_efta_per_x_eec_efta, noconstant
```

Kennedy Round

Sigma

```
egen SD_kennedy=sd(lnpci), by (year kennedy)
gen kennedy_times_kennedy_per=kennedy*kennedy_per
gen year_times_kennedy_per=year*kennedy_per
gen year_times_kennedy=year*kennedy
gen year_x_kennedy_x_kennedy_per=year*kennedy*kennedy_per
reg SD_kennedy kennedy_per kennedy kennedy_times_kennedy_per year
year_times_kennedy_per year_times_kennedy year_x_kennedy_x_kennedy_per
```

Delta Z

```
gen y=lnpci
egen y_bar_t_kennedy = mean(y), by (year kennedy)
gen z_kennedy=y-y_bar_t_kennedy
sort country year
by country: gen lead1_z_kennedy=z_kennedy[_n+1]
gen del_z_kennedy=lead1_z_kennedy-z_kennedy
gen z_times_kennedy_per = z_kennedy*kennedy_per
gen z_times_kennedy = z_kennedy*kennedy
gen z_x_kennedy_per_x_kennedy=z_kennedy*kennedy_per*kennedy
reg del_z_kennedy z_kennedy z_times_kennedy_per z_times_kennedy
z_x_kennedy_per_x_kennedy, noconstant
```

Results

EEC

Sigma

Source	SS	df	MS
Model	35.7931508	7	5.11330725
Residual	.513560368	3,355	.000153073
Total	36.3067111	3,362	.010799141

Number of obs	=	3,363
F(7, 3355)	=	33404.34
Prob > F	=	0.0000
R-squared	=	0.9859
Adj R-squared	=	0.9858
Root MSE	=	.01237

SD_eec	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
eec_per	-7.152554	.314319	-22.76	0.000	-7.768831	-6.536278
eec	31.39782	1.296319	24.22	0.000	28.85616	33.93947
eec_times_eec_per	-3.507912	1.707189	-2.05	0.040	-6.855149	-.1606753
year	.002327	.0001221	19.05	0.000	.0020875	.0025664
year_times_eec_per	.0036511	.0001605	22.74	0.000	.0033364	.0039659
year_times_eec	-.016308	.0006634	-24.58	0.000	-.0176088	-.0150073
year_times_eec_times_eec_per	.0017846	.0008719	2.05	0.041	.0000751	.0034941
_cons	-3.716186	.2386716	-15.57	0.000	-4.184143	-3.24823

Delta Z

Source	SS	df	MS
Model	.018733471	4	.004683368
Residual	14.1630904	1,458	.009714054
Total	14.1818239	1,462	.00970029

Number of obs	=	1,462
F(4, 1458)	=	0.48
Prob > F	=	0.7489
R-squared	=	0.0013
Adj R-squared	=	-0.0014
Root MSE	=	.09856

del_z_eec	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
z_eec	.0026254	.0054506	0.48	0.630	-.0080664	.0133172
z_times_eec_per	-.0032978	.0066795	-0.49	0.622	-.0164003	.0098047
z_times_eec	-.0472707	.0406393	-1.16	0.245	-.1269884	.0324469
z_times_eec_per_times_eec	.0086325	.0721198	0.12	0.905	-.1328372	.1501022

EFTA

Sigma

Source	SS	df	MS			
				Number of obs	=	12,390
				F(7, 12382)	=	16666.67
Model	471.939743	7	67.4199633	Prob > F	=	0.0000
Residual	50.0876176	12,382	.004045196	R-squared	=	0.9041
				Adj R-squared	=	0.9040
Total	522.027361	12,389	.04213636	Root MSE	=	.0636

SD_efta	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
efta_per	-12.49015	.3888719	-32.12	0.000	-13.2524	-11.7279
efta	-19.30872	4.295318	-4.50	0.000	-27.72821	-10.88922
efta_times_efta_per	12.44256	2.112115	5.89	0.000	8.302483	16.58263
year	-.0100704	.0004041	-24.92	0.000	-.0108625	-.0092783
year_times_efta_per	.0064405	.0001988	32.40	0.000	.0060508	.0068301
year_times_efta	.009601	.0021949	4.37	0.000	.0052986	.0139034
year_times_efta_times_efta_per	-.0064311	.0010796	-5.96	0.000	-.0085473	-.0043149
_cons	20.52165	.7908321	25.95	0.000	18.9715	22.07181

Delta Z

Source	SS	df	MS			
				Number of obs	=	9,811
				F(4, 9807)	=	4.35
Model	.245580626	4	.061395157	Prob > F	=	0.0016
Residual	138.559651	9,807	.014128648	R-squared	=	0.0018
				Adj R-squared	=	0.0014
Total	138.805232	9,811	.014147919	Root MSE	=	.11886

del_z_efta	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
z_efta	.0039359	.0054612	0.72	0.471	-.0067693	.0146411
z_times_efta_per	-.0043036	.0028273	-1.52	0.128	-.0098457	.0012384
z_times_efta	-.0203958	.0590868	-0.35	0.730	-.1362182	.0954265
z_times_efta_per_times_efta	.0044701	.0348306	0.13	0.898	-.063805	.0727451

EEC & EFTA

Sigma

Source	SS	df	MS
Model	738.960565	7	105.565795
Residual	70.5794181	12,802	.005513156
Total	809.539983	12,809	.063200873

Number of obs	=	12,810
F(7, 12802)	=	19147.98
Prob > F	=	0.0000
R-squared	=	0.9128
Adj R-squared	=	0.9128
Root MSE	=	.07425

SD_eec_efta	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
eec_efta_per	18.84021	.324456	58.07	0.000	18.20422	19.47619
eec_efta	63.0309	2.558786	24.63	0.000	58.0153	68.0465
eec_efta_times_eec_efta_per	-25.75416	1.267041	-20.33	0.000	-28.23775	-23.27057
year	.0240293	.0003336	72.04	0.000	.0233755	.0246831
year_times_eec_efta_per	-.0095747	.0001652	-57.96	0.000	-.0098985	-.0092509
year_times_eec_efta	-.032426	.0013026	-24.89	0.000	-.0349793	-.0298727
year_x_eec_efta_x_eec_efta_per	.0130951	.0006451	20.30	0.000	.0118305	.0143596
_cons	-46.28321	.6552381	-70.64	0.000	-47.56758	-44.99885

Delta Z

Source	SS	df	MS
Model	.270194423	4	.067548606
Residual	139.309451	10,212	.01364174
Total	139.579646	10,216	.013662847

Number of obs	=	10,216
F(4, 10212)	=	4.95
Prob > F	=	0.0005
R-squared	=	0.0019
Adj R-squared	=	0.0015
Root MSE	=	.1168

del_z_eec_efta	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
z_eec_efta	.0017188	.0035408	0.49	0.627	-.0052218	.0086594
z_times_eec_efta_per	-.0034199	.0019381	-1.76	0.078	-.0072189	.0003792
z_times_eec_efta	-.032777	.0385641	-0.85	0.395	-.1083701	.0428161
z_x_eec_efta_per_x_eec_efta	.0105027	.022809	0.46	0.645	-.0342074	.0552128

Kennedy Round

Sigma

Source	SS	df	MS
Model	360.253815	7	51.4648308
Residual	143.381878	12,802	.011199959
Total	503.635693	12,809	.039318892

Number of obs	=	12,810
F(7, 12802)	=	4595.09
Prob > F	=	0.0000
R-squared	=	0.7153
Adj R-squared	=	0.7152
Root MSE	=	.10583

SD_kennedy	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
kennedy_per	44.20493	1.440041	30.70	0.000	41.38224	47.02763
kennedy	108.0744	6.027408	17.93	0.000	96.2598	119.889
kennedy_times_kennedy_per	-47.7117	3.005908	-15.87	0.000	-53.60373	-41.81967
year	.0523215	.0014688	35.62	0.000	.0494425	.0552005
year_times_kennedy_per	-.0224553	.0007325	-30.65	0.000	-.0238911	-.0210194
year_times_kennedy	-.0549527	.0030659	-17.92	0.000	-.0609623	-.0489432
year_x_kennedy_x_kennedy_per	.0242371	.0015291	15.85	0.000	.0212399	.0272343
_cons	-102.0715	2.887551	-35.35	0.000	-107.7315	-96.41146

Delta Z

Source	SS	df	MS
Model	.315005065	4	.078751266
Residual	141.64519	10,212	.013870465
Total	141.960195	10,216	.013895869

Number of obs	=	10,216
F(4, 10212)	=	5.68
Prob > F	=	0.0001
R-squared	=	0.0022
Adj R-squared	=	0.0018
Root MSE	=	.11777

del_z_kennedy	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
z_kennedy	-.0036524	.0063188	-0.58	0.563	-.0160385	.0087337
z_times_kennedy_per	-.0010293	.0032715	-0.31	0.753	-.0074421	.0053835
z_times_kennedy	.0023121	.0116135	0.20	0.842	-.0204527	.0250769
z_x_kennedy_per_x_kennedy	-.0000773	.0061199	-0.01	0.990	-.0120735	.0119189