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Abstract

The volatility of Foreign Direct Investment (FDI) flows, particularly those into ASEAN countries is well known. Still researchers will continue to use regression approaches to analyze this volatility. This paper is an exploratory approach to analyzing the behavior of FDI with no attempt to design a complete regression model. Our approach is probabilistic in that we treat the FDI flows from home or source country to various members of ASEAN as random independent events over the time period 1999-2003 and over ISIC manufacturing sectors. We then show how closely the random plots of FDI fit two common cumulative distribution functions (CDF), the Gumbel and the Weibull and whether the plots are from multi-regimes or not. A brief econometric analysis shows FDI volatility within the ISIC industrial sectors. The essential thesis (or hypothesis) is that if capital markets are in a general equilibrium across hosts, home, industrial sectors, and time, then the return on capital (the marginal efficiency of capital) is equalized everywhere, and a home investor's dollar will be randomly allocated across hosts, industrial sectors, and time.

Acknowledgements: Our thanks go to Ms. Piyaphan Changwatchai, a Ph.D. graduate student in economics who assembled the raw data from ASEAN Statistical Yearbook 2006 and put it in spread sheet form. From the raw data, we were then able to make the various subsamples given in the presentation

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Introduction

Virtually every research paper on FDI and South East Asia countries recognizes the extreme volatility of FDI flows from home to hosts. For this reason, rarely are FDI inflows used as a dependent variable in a regression analysis (see, Uttama, 2005; Gottschalk and Hall, 2007; and Plummer, 2007). Instead, when available the FDI stock data are used. Yet, one cannot help to believe that volatility itself has important information for understanding the behavior of the FDI flows. And this information can help us understand the notion of uncertainty in the Knight (1921) and Keynes (1936) sense. Our approach to examining FDI flows is largely exploratory at this stage. We are not attempting to build a full forecasting model. This attempt will come at a much later time.

Exploratory Method

The exploratory method we use comes from extreme value theory (see, Gander, 2008, working paper, University of Utah, for a full discussion.). This is an area of statistical and probability theory pioneered by E.J. Gumbel (1954). Originally, it was used to examine the peak discharges every year for the Mississippi and other rivers. From these peaks, a probability scale can be constructed to forecast the most probable discharge. To construct the probability scale, the time-ordered discharges (x) must first be put in natural order from low to high. The discharges are assumed to be random and independent of time. Plots that were outside his model, were extreme values and presumably from a different universe or regime. The Gumbel model has a CDF given by $\Pr(x \leq x^*) = \exp(-e^{-y})$, where $y = \alpha(x - u)$, a linear function. As x^* approaches infinity, the CDF approaches one.

The interesting feature of the Gumbel approach is that when the random events (ordered from low to high) are plotted on probability paper (PP) against x, the discharge, they fall along a linear function, if they are from the same universe. But, if the extreme values come from a different universe, then, the high plots (the reverse if we are focusing on low values) will deviate significantly from the linear path representing the plots from the initial universe. Throughout the paper, we refer to a change in a universe as a regime change. Such a change can be thought of as a change in fundamental economic conditions which show up in a model as parameter changes. An example of a regime change can, in effect, be thought of as a blip or "fat tail" occurring on the upper end of a given probability density function (pdf) and correspondingly on the CDF. We leave to the listener to look at the literature on "fat tails" and its correspondent notion, a "Black Swan" (see, Mandelbrot, 1963; Fama, 1965; and Taleb, 2007, and others). In other words when random events do not follow a prescribed model or universe (like the probability of an ace card in a normal card deck), a regime change is suspected.

Rather than use probability paper to plot the points, by taking the double log of the CDF, we can plot the points using XLS as a linear function, where $-Ln(-Ln(F(x))) = y = \alpha(x - u)$, where α and u are constants. To simplify, the F(x) is often approximated by $F(t) \sim (t - .3)/(n + .4)$, where t follows the low to high rankings of the x's.

An alternative probability model is a Weibull general exponential two-parameter function, $F(x) = 1 - \exp\text{-}(\lambda x)^{\beta}$, which in double-log form is $Ln(Ln(1/(1- F(x))) = y = \beta Ln\lambda + \beta Lnx(t)$. This is a function linear in the logs as opposed to Gumbel's which is linear in the absolute. They are different models and we get sometimes conflicting results. We use both models, however, we focus on the Weibull due to time considerations. The sample consists of 2789 observations on FDI flows over 1999-2003 for a limited number of ASEAN members as hosts and EU, Japan, and the USA as home countries, for ISIC from 15 to 37 (see, appendix for a list of code defintions). The source of the data is ASEAN Statistical Yearbook, 2006 with the data in millions of US dollars.

The point of our argument is that the FDI's volatility can be examined by these models which can be used to determine regime changes. Exactly why the regime change occurs is a matter of future research. The FDI flows are so erratic, it is virtually impossible to explain their behavior, without first having a clear picture of how FDI itself behaves. This is not to say that a deeper examination of the FDI's can not provide some causal explanation. As currently defined, a MNE subsidiary's FDI net flow is the sum of equity changes for the subsidiary + internal home loans + retained earnings of the subsidiary in the host country + asset valuation adjustments. Any one of these components can and does cause volatility and each in theory has its own causal factors such as exchange rate changes and changes in the interest rate. But, equally important are changes in MNE policies affecting its subsidiaries and changes in the business climate of the host country. Much of the data needed for a deeper examination is either not available or difficult to come by. The FDI components are published by host and by home country but not by 2-digit ISIC code.

To get around the lack of FDI component data, we examine FDI volatility from the perspective of randomness within ISIC industrial sectors.

Empirical Results

As indicated earlier, the FDI inflows are classified by hosts, home, industrial ISIC, and year (1999-2003). The core ASEAN hosts are Thailand, Malaysia, Indonesia, the Philippines, and Viet Nam. Singapore does not supply FDI by sectors, only by total investment of domestic and foreign with no breakdown. The main home sources are EU, Japan, and the USA. Singapore is a home source with respect to the five core ASEAN members. Some times our data will include Myanmar, Cambodia, Lao, and Brunei, depending on the availability of the data. In our econometric modeling, the ISIC sectors are treated as panels and they are unbalanced. A given home invests in some but not all hosts and sectors and years. Thus, there are gaps across hosts, across ISIC's and across years. The gaps will affect our choice of econometric models considered later.

To get a general sense of the relative importance of the developed investors and who the developing hosts are, roughly, over the period1995-2005, the EU was by far the largest investor in ASEAN (some $79 billion), swamping the USA by 60 percent and Japan by 3 to 1. The largest ASEAN host over this period from the world as a whole was by far Singapore with $143 Billion, next was Malaysia with $45 Billion and Thailand with $45 Billion, then the Philippines with $14 Billion and Indonesia with $12 Billion. South Korea, Hong Kong, and Taiwan together invested a relatively small amount ($20 Billion) in ASEAN (see, Plummer, 2007).

Time and space limit us to only a few graphs, two for each home country using all years and all sectors and one for Singapore. More graphs for selected individual industrial sectors are available from Gander's (2009) web site.

The theory behind our probability interpretation is admittedly over simplified and heuristic. If investment markets were perfectly competitive across all hosts and all industrial sectors, the MEK's would be equal to the Global equilibrium interest rate. No matter where you put your dollar of investment, you expect the same return. That being assumed (hypothized), an FDI allocation across all hosts and across all sectors (leaving out the issues that arise with vertical versus horizontal investment) will be random for a given home source.

Figure 1a shows the CDF of a Weibull model for EU investments to eight ASEAN (the core five plus Lao, Cambodia, and Myanmar having a very small role) for all sectors and years. As indicated earlier, the FDI's are re-ordered naturally and assumed to be random draws independent of time. This assumption will hold throughout the presentation. As explained earlier, a log-linear function through the plots indicates for a tight fit that the plots represented by the function are from a given universe and by implication satisfy the assumptions of randomness and independence. We leave it to the reader to visually draw his/her own imaginary line. About at x=logFDI ~ 3.5, the upper plots (extreme values) appear to deviate significantly below the line, suggesting a regime change. The $Pr(x \leq x^*)$ will be less than what it would be if the plots continued along the imaginary line. A more detailed examination would show that these extreme values are very much spread over the five years and the ASEAN five hosts and industrial sectors 23, 24, 32, and 35 (see, Gander's web site, 2009).

On the other hand, a more generous interpretation of Figure 1a suggests that all the plots come from the same regime. In other words, all the FDI investments into ASEAN for the period 1999-2003 for all sectors are random and independent of each other, for the fit to the CDF Weibull is arguably very good.

For purposes of comparison, Figure 1b shows the plots for the Gumbel linear model. The fit is not as consistent as before. The upper tail appears linear but the lower tail appears to have its own regime. In fact some 330 of the 354 plots occur in this lower section. One could argue that based on the Gumbel model, there are two distinct random regimes in Figure 1b. It is not surprising that sometimes, as in this case, the two models can give different results, depending on one's interpretation of the fits.

As indicated before, we refer the reader to Gander's (2009) web site to see the results from using EU as the source or home country for FDI into ASEAN for the period 1999-2003, for a selected number of ISIC sectors. As before, generally, both the Weibull plots and the Gumbel plots suggest regime changes for sectors 15, 17, 28, and 32 (see, Gander's web site, Figures 2, 3, 4, and 5). As indicated earlier, a more detailed examination of FDI sector volatility will follow shortly.

Next, we examine the FDI flows from Japan to seven ASEAN members. First, taking all industrial sectors and years together, Figure 2a shows the Weibull plots and Figure 2b shows the Gumbel plots. Both the Weibull plots and the Gumbel plots appear to have been generated from two different universes (involving in some cases a single extreme value). For the Weibull model for sectors 15, 18, 24, and 32, the plots generally appear to be from a given universe (see, Gander's web site, 2009). Again, we leave to later to examine sector FDI volatility.

We next consider the USA as the source country and use only the Weibull model. FDI flows from the USA to six ASEAN members for all industrial sectors and years create a Weibull multi-regime pattern similar to that obtained for the EU and Japan. Figure 3 shows the plots for all sectors and all years. While the actual parameter estimates for the Weibull CDF model using all sectors and all years would be different among the three home sources considered, the general exponential form is the same. In other words, regardless of the home source of FDI, the randomness from different universes is still there. The overall evidence for this last point for the three source countries can be viewed from the figures in the aforementioned Gander web site (2009). As before, FDI sector volatility will be considered shortly.

As a final point, the Weibull plots for all sectors and all years of the FDI flows into ASEAN from Singapore as a home or source country and five core ASEAN members as before plus Lao, Cambodia, Brunei, and Myanmar as the hosts can be viewed from Figure 4 (Figure 15 in the aforementioned Gander web site, 2009). Not surprising, perhaps, based on the evidence given before, the plot pattern suggests as before, that the investments from Singapore are distributed randomly across all sectors and hosts and appear, arguably, to be from different universes. A more detailed examination on an industry-specific basis would yield the same results.

Some Econometric Results

It appears from the evidence that yearly FDI's are random and independent from a given home country across all hosts, industrial sectors, and all years, and not necessarily from a given universe. Whether this randomness shows regime changes or not depends on how one interprets the plot fits (how many sigmas to accept) and the probability model used (Weibull vs Gumbel). The volatility of yearly FDI is reflected in the extreme values that occur and the changes in the variances over time and across industrial sectors. Here, with a brief econometric treatment, we try to model such FDI volatility, remembering that while we do not know which of the four components is responsible for the volatility, we can examine FDI sector volatility using ISIC sectors as panels. We focus on GLS, panel analysis, fixed and random effects. In particularly, we are concerned with the within-group (the ISIC's) heteroscedasticity. All our statistical results were obtained by running STATA regressions for OLS, xtreg, and xtgls.

To begin our econometric comments, examine Table 1. It shows the key results in brief form for an FDI model using industry dummy variables (DV1 for sectors 15 to 18, DV2 for sectors 19 to 23, and DV3 for sectors 24 to 37, with DV1 as the reference industry), host country dummy variables given by DVCi (where i is for the various ASEAN members), and year. Robust OLS, robust xtreg for RE and FE, and FGLS for panel analysis are reported briefly in the table.

As is evident from the results in Table 1, about 20 out of a possible 80 coefficients overall are significant (at the 10 percent level or lower). The relatively poor statistical results for EU and Japan, the largest suppliers of FDI, are in contrast to those for the USA. Still, we have to concede that extreme FDI volatility dominates the estimates overall. Such dominance will be more evident from the panel heteroscedasticity that follows.

The volatility of FDI is capture by the within-panel heteroscedasticity as measured by the panel's residual variance. The panel variances are recovered from the e(Sigma) matrix of the xtgls runs for each home source to all its hosts countries and all its ISIC industrial sectors. Table 2 shows the variances for each sector for each home, with the corresponding host countries handled as dummy variables.

For source EU, over all its hosts, the sectors with extremely high variability are 22 (publishing and printing), 23 (petroleum), 32 (radio, TV, and communication), and 35 (transportation equipment). The range of volatility is from 4.0 to 623,799. For source Japan, the high volatility sectors 25 (rubber and plastics), 27 (basic metals), and 32. The range of volatility is from 848 to 333,445. For source USA, the high volatility sectors are 23 and 32. The range of volatility is from 626 to 209,081.

What we learn from the behavior of the variances is that FDI volatility covers a wide range over all ISIC sectors and it is especially high in sectors 22, 23, 25, 27, 32, and 35. Sector 32 volatility is high for all three FDI sources. Even when each home is run separately on each host country, the high volatility across the sectors is still prevalent (not reported). Such volatility behavior cast doubt on any attempts to use traditional regression modeling to explain such behavior.

Conclusions

So, what is the usefullness of all these random patterns? At the outset, we stated that this presentation was to be an exploratory examination of the behavior of FDI between home and hosts over various 2-digit industrial ISIC's. The exploration included a brief econometric analysis which generally showed extremely high FDI volatility across all hosts and all sectors for a given home source.

Based on our sample of home, hosts, and industrial sectors, we found generally that the FDI plot patters are random, best fit for a Weibull CDF, and consistently multi-regime in origin. This consistence suggests that the world of FDI as far as ASEAN members are concerned is a random world. To use an analogy, for a given home or source country, FDI inflows are being scattered randomly within each sector and across all sectors and across all hosts. While time did not allow a presentation of FDI flows from a given home to a given host, for all sectors, the results we have found in our research are still essentially the same as we have found for a group of hosts. Of course, the multi-regime results can be affected by the degree of disaggregation, so the pattern for a given home to a given hosts for a given industrial sector can be affected by the number of plots available.

Are these results surprising? In some ways they are not. Personal income frequency distributions are usually found to be log normal (Weibull is just more general). The frequency distributions for firm sizes are also log normal. The corresponding CDF's are also log normal. We have to ask ourselves, what is it about such economic phenomena that display such commonality or universality? Our results present a different (its own) universality. Our results may not be surprising but they represent the outcome of an original attempt and use of statistical methodology to examine FDI volatility.

The policy implications of our findings may be disappointing and perhaps even objectionable to many readers. Since the FDI patterns are random and generally from multiple regimes, it means that they are determined by an infinitely large number of rather small events (economic and non-economic), no one of which or group of which can be controlled by forces outside of the economic system. This may over state our case somewhat, but it remains for future research to identify what key factors determine the values of the parameters of, say, the Weibull distribution and how these parameters change. As indicated earlier, the volatility of FDI should not be averaged away by traditional regression analysis. There is information to be had and we hope our presentation sheds some light on what that information is.

Acknowledgement: .

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ANNEX

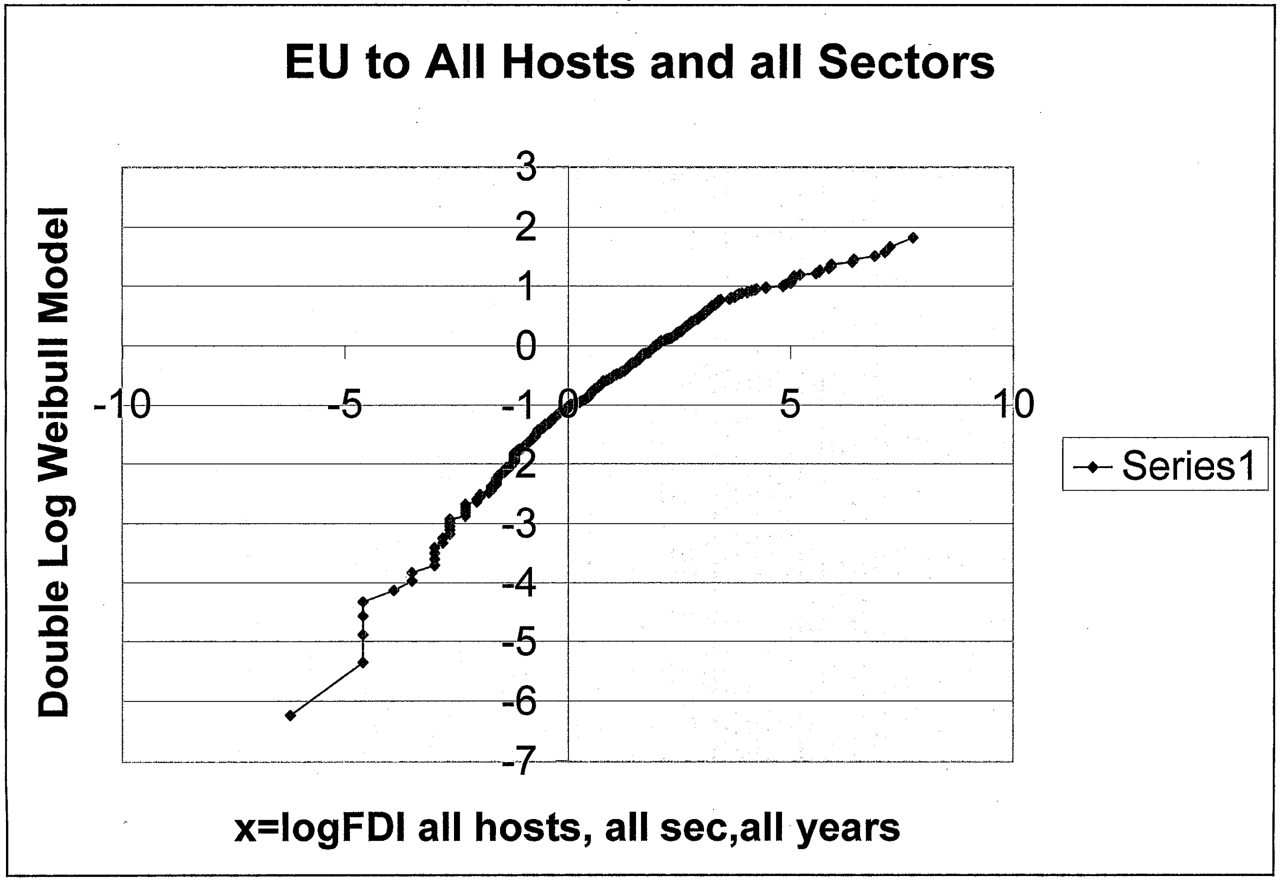
LIST OF INTERNATIONAL STANDARD INDUSTRIAL CLASSIFICATION CODE REV. 3 USED IN ADMINISTRATIVE FOREIGN INVESTMENT (FI) DATA

ISIC CODE	MANUFACTURING SECTOR
15	Manufacture of Food Products and Beverages
16	Manufacture of Tobacco Products
17	Manufacture of Textiles
18	Manufacture of Wearing Apparel; Dressing and Dyeing of Fur
19	Tanning and Dressing of Leather; Manufacture of Luggage, Handbags, Saddlery, Harness and Footwear
20	Manufacture of Wood and Wood Products and Cork, Except Furniture; Articles of Straw and Plaiting
21	Manufacture of Paper and Paper Products
22	Publishing, Printing and Reproduction of Recorded Media
23	Manufacture of Coke, Refined Petroleum Products and Nuclear Fuel
24	Manufacture of Chemicals and Chemicals Products
25	Manufacture of Rubber and Plastics Products
26	Manufacture of Other Non-Metallic Mineral Products
27	Manufacture of Basic Metals
28	Manufacture of Fabricated Metal Products, Except Machinery and Equipment
29	Manufacture of Machinery and Equipment N.E.C
30	Manufacture of Office, Accounting and Computing Machinery
31	Manufacture of Electrical Machinery and Apparatus N.E.C
32	Manufacture of Radio, Television and Communication Equipment and Apparatus
33	Manufacture of Medical, Precision and Optical Instruments, Watches and Clocks
34	Manufacture of Motor Vehicles, Trailers and Semi-Trailers
35	Manufacture of Other Transport Equipment
36	Manufacture of Furniture; Manufacturing N.E.C
37	Recycling
Others	

Source: UN International Standard Industrial Classification of All Economic Activities (Series M No.4 REV 3)
N.E.C: Not Elsewhere Classified

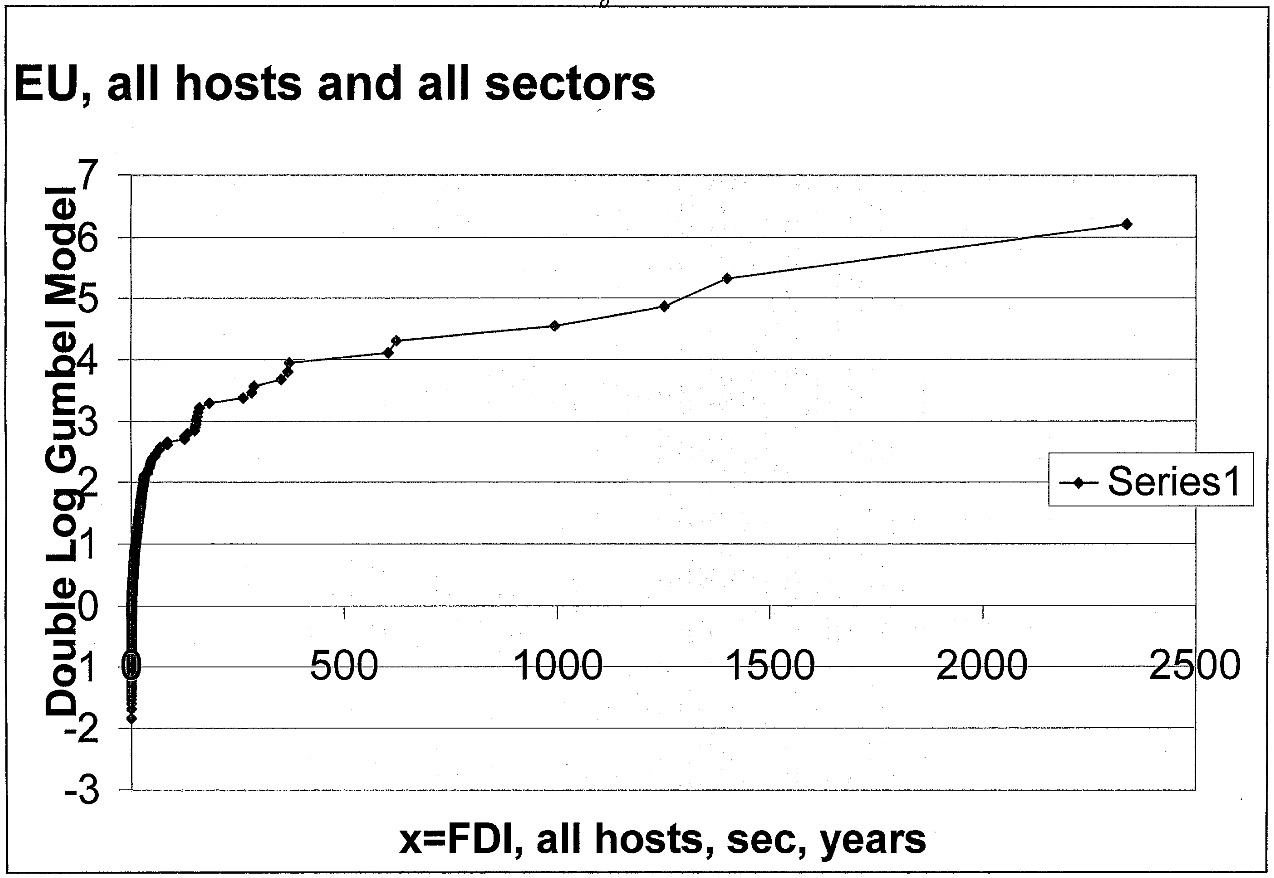
2/26/09

Fig 1a


EU to All Hosts and all Sectors
Double Log Weibull Model
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-10
-5
0
5
10
x=logFDI all hosts, all sec,all years
Series1

2/26/09

Fig 1b


EU, all hosts and all sectors
Double Log Gumbel Model
7
6
5
4
3
2
1
0
-1
-2
-3
0
500
1000
1500
2000
2500
Series1
x=FDI, all hosts, sec, years

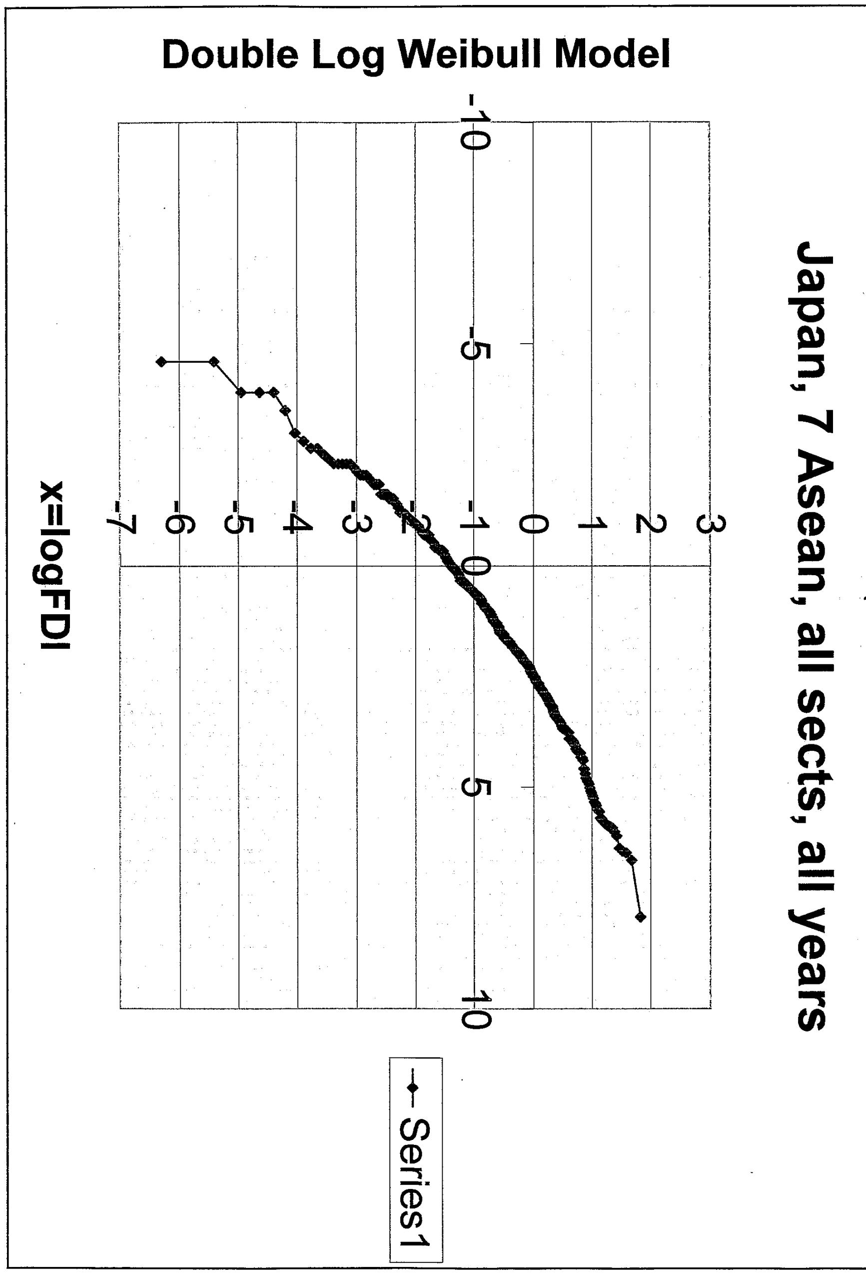
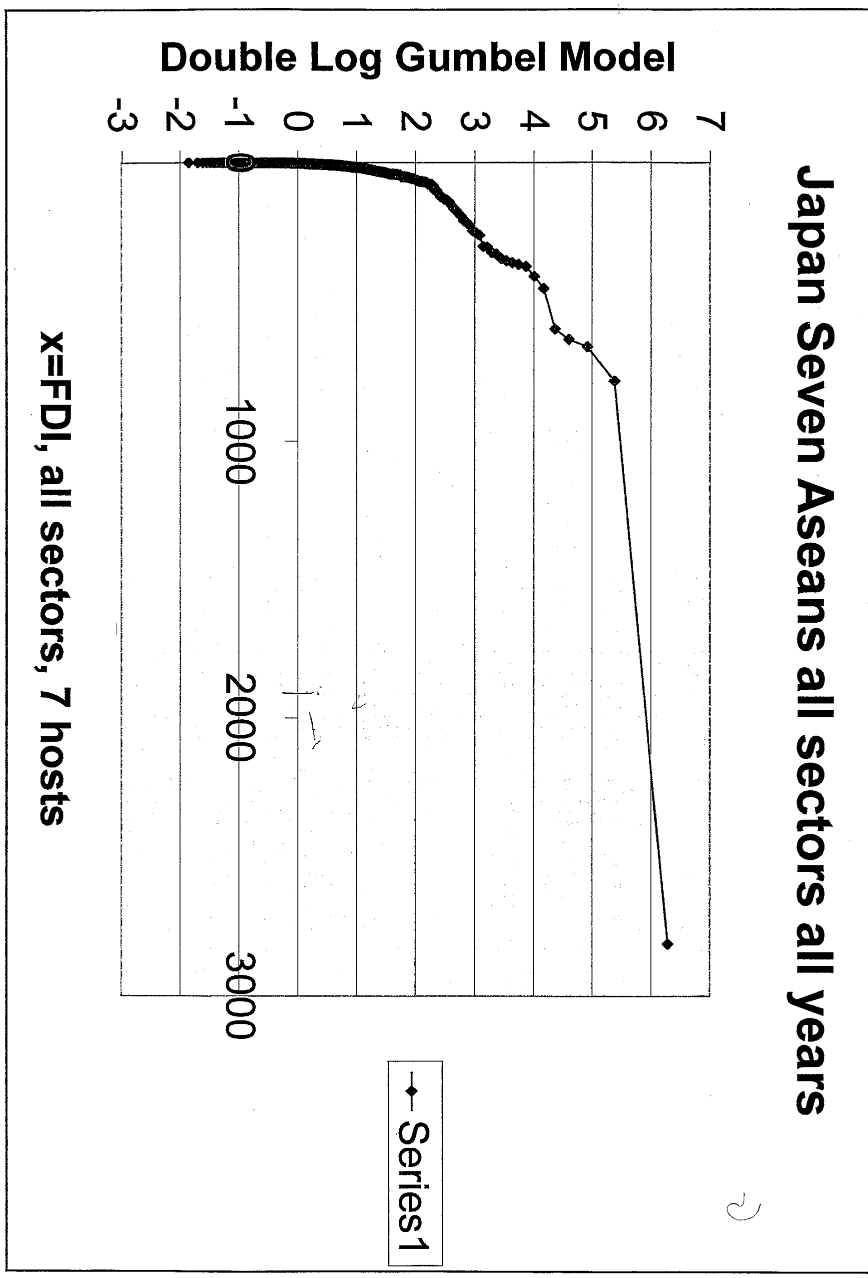

Double Log Weibull Model
Japan, 7 Asean, all sects, all years
x=logFDI
Series1

fig 6a


Double Log Gumbel Model
Japan Seven Aseans all sectors all years
-3
-2
-1
0
1
2
3
4
5
6
7
1000
2000
3000
x=FDI, all sectors, 7 hosts
Series1

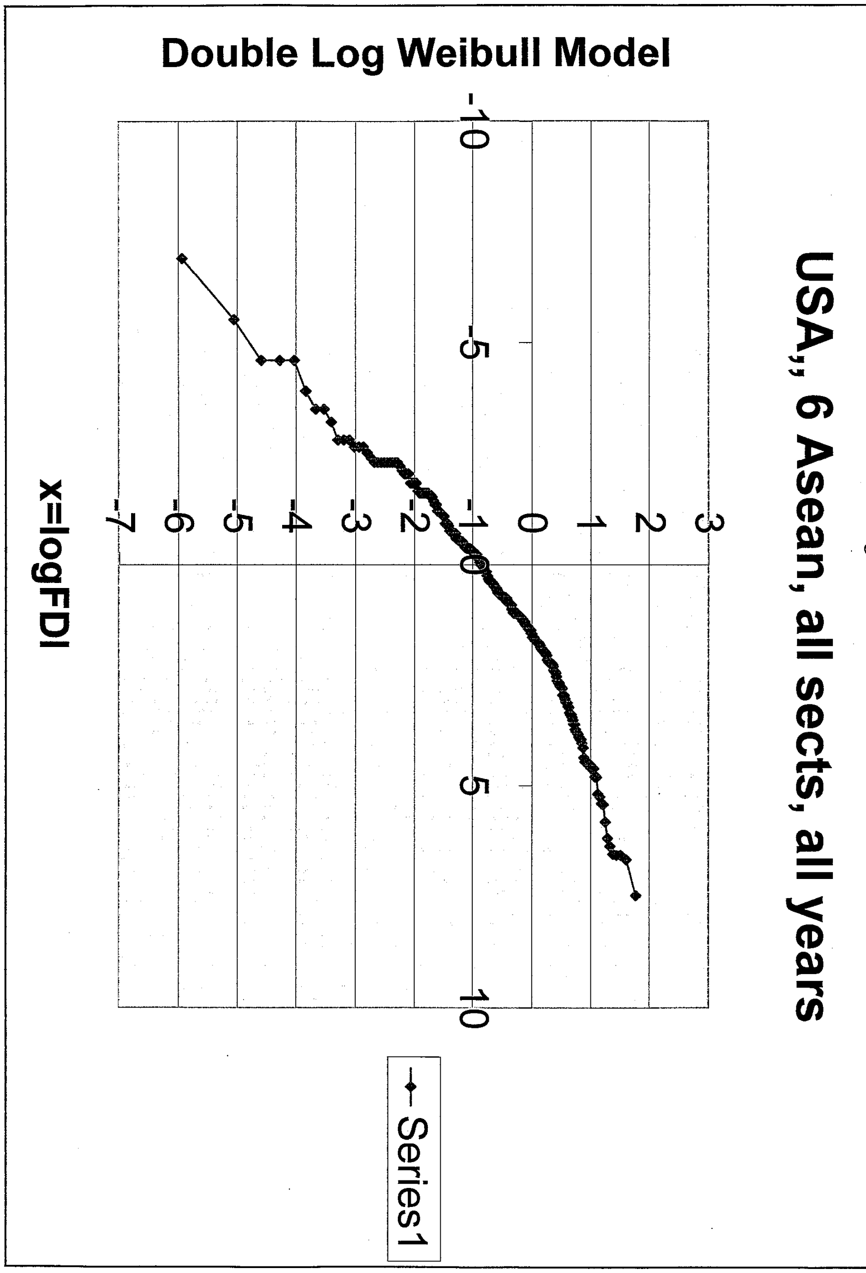

USA,, 6 Asean, all sects, all years
Double Log Weibull Model
x=logFDI
Series1
-10
-5
5
10
3
2
1
0
-1
-2
-3
-4
-5
-6
-7

Fig 11

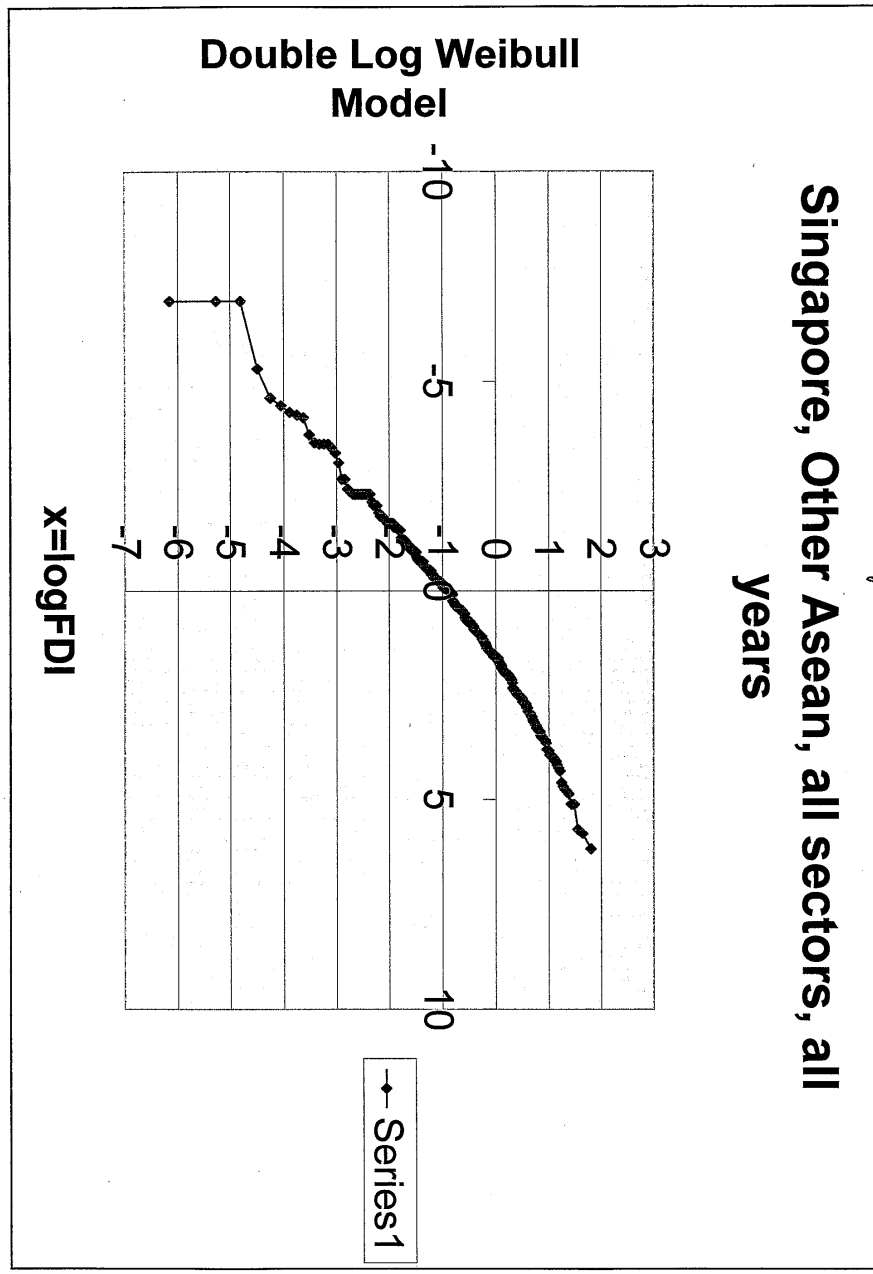

Double Log Weibull Model
Singapore, Other Asean, all sectors, all years
Fig 15
-10
-5
5
10
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
x=logFDI
Series1

Table 1. Brief Results Running the Full FDI Model

Home	host	Robust OLS	Robust xtreg	FGLS-xtgls
EU	C,I,L,M,	Rsq=.046(sig)	RE & FE	none sig
(n=351)	P,T,V	DVC4(.020)	none sig	sigma mat
		DVC6(.052)		
JAPAN	I,M,P,	Rsq=.055(sig)	RE	DV3(.000)
(n=366)	T,V	DV3(.000)	DV3(.000)	DVC3(.090)
		DVC5(.007)	DVC5(.077)	Wald(sig)
			Wald(sig)	sigma mat
			FE, none sig	
USA	I,M,P,	Rsq=.053(sig)	RE	none sig
	T,V	DV3(.025)	DVC2(.019)	sigma mat
		DVC2(.030)	DVC4(.010)	
		DVC4(.008)	DVC5(.063)	
			Year(.070)	
			Int(.070)	
			Wald(sig)	
			FE	
			DVC2(/032)	
			Year(.068)	
			Int(.068)	

Notes: C=Cambodia, I=Indonesia, L=Lao, M=Malaysia, P=the Philippines, T=Thailand, and V=Viet Nam. The (.) contains the p values. The (sig) is =< 10 percent.

Table 2. Heteroscedastic Sigmas (Within Group Variances) by Sources

ISIC	EU	ISIC		JAPAN	ISIC	USA	ISIC
15	4,000	26	605	1,082	10,764	1,290	2,189
16	4	27	615	n/a	18,759	1,793	2,546
17	308	28	527	909	3,865	3,190	2,295
18	818	29	654	1,349	5,888	633	1,432
19	5,478	30	680	848	1,607	626	829
20	5,577	31	459	1,231	2,145	2,204	2,405
21	2,574	32	47,300	9,628	29,930	2,264	209,081
22	15,812	33	464	1,262	2,142	4,637	1,322
23	623,799	34	952	1,958	14,839	140,983	1,409
24	8,130	35	57,863	19,917	2,579	4,198	4,162
25	1,296	36	616	333,445	2,784	1,092	2,817
		37	466		965		639

Notes: There are 23 2-digit ISIC sectors, 15 to 37. See Appendix for definitions. The three Home or sources are as before. The left side is ISIC column one and the right side is ISIC column two. The within group variances are over time and over hosts for a given source and a given ISIC sector. In effect, the hosts are pooled and result in multiple observations for a given year, source, and sector.