

# double-gompertz

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## 1 Interpolazione dati cumulativi dei contagi con funzione Gompertz doppia

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La curva dei contagi totali segue una forma approssimativamente sigmoide (ref).

$$f(x) = \frac{a}{1 + e^{k(b-x)}} + \varepsilon$$

Dall'analisi delle curve interpolate con funzione sigmoide però risulta evidente che la pendenza della curva prima del flesso è differente dalla pendenza dal flesso al massimo (ref).

Due differenti funzioni sigmoidi descrivono più correttamente la curva prima del flesso (Logistic 1) e dopo il flesso (Logistic 2) ref.

Una possibile soluzione per interpolare su una funzione che descriva meglio l'andamento della curva viene dalla funzione di Gompertz doppia, utilizzata ad esempio in agraria per la descrizione dell'accrescimento dei frutti (ref).

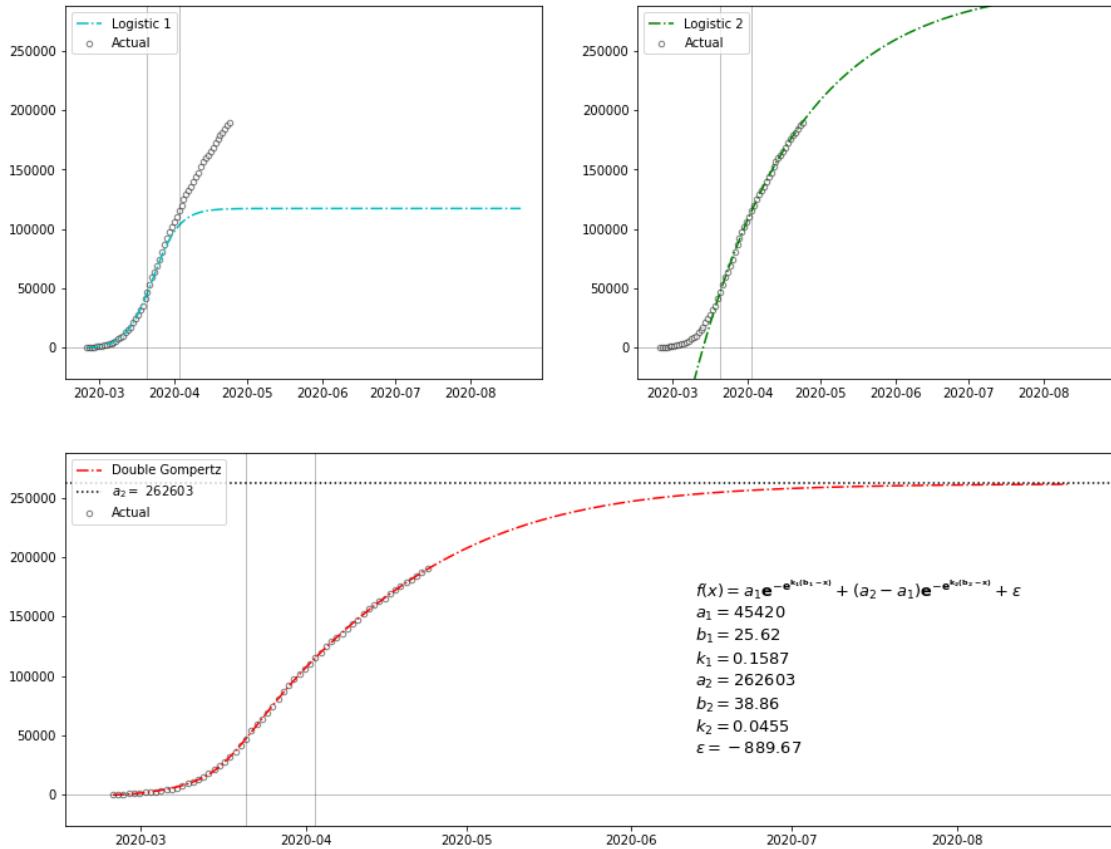
$$g(x) = a_1 e^{-e^{k_1(b_1-x)}} + (a_2 - a_1) e^{-e^{k_2(b_2-x)}} + \varepsilon$$

L'interpolazione dei dati (laddove siano sufficienti e coerenti) su questa funzione, segue meglio l'andamento della curva dei contagi.

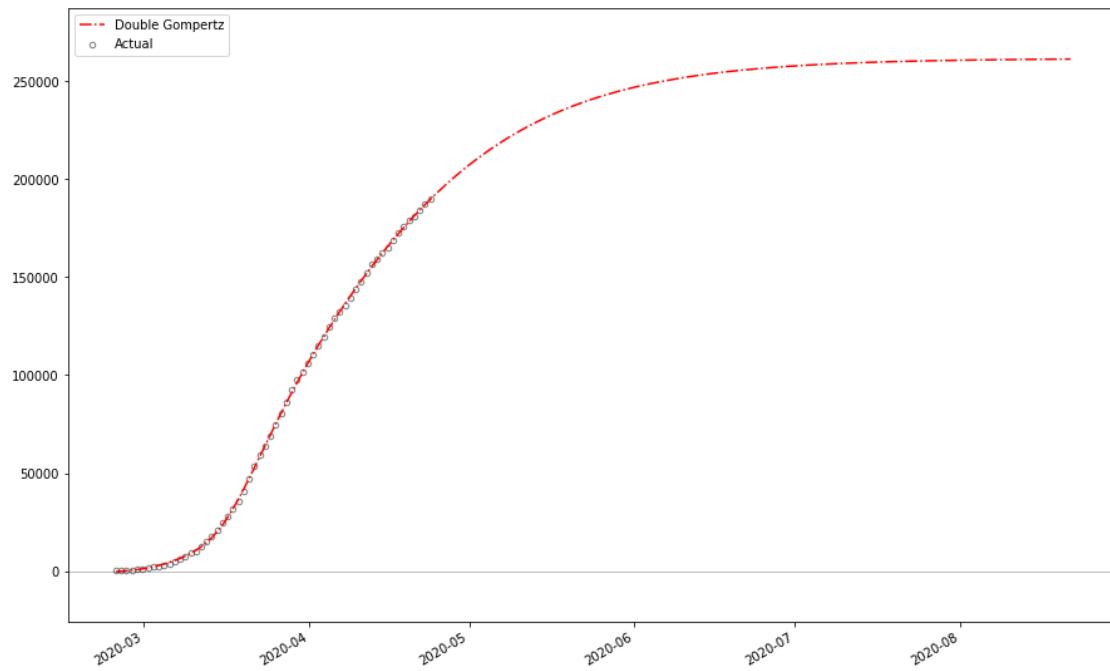
Dal grafico dei contagi totali italiani si può notare che - la funzione **Logistic 1** descrive correttamente la prima parte della curva ma - non è in grado di descrivere la curva dopo il flesso - porta sicuramente ad una notevole sottostima della previsione dei contagi totali - la funzione **Logistic 2** descrive correttamente la curva dopo il flesso ma - non è in grado di descrivere la curva prima del flesso - può portare ad una sovrastima della previsione dei contagi totali

Interpolando i dati invece su funzione di Gompertz doppia, la curva è descritta correttamente prima e dopo flesso ed è possibile una maggior precisione nella stima delle previsioni.

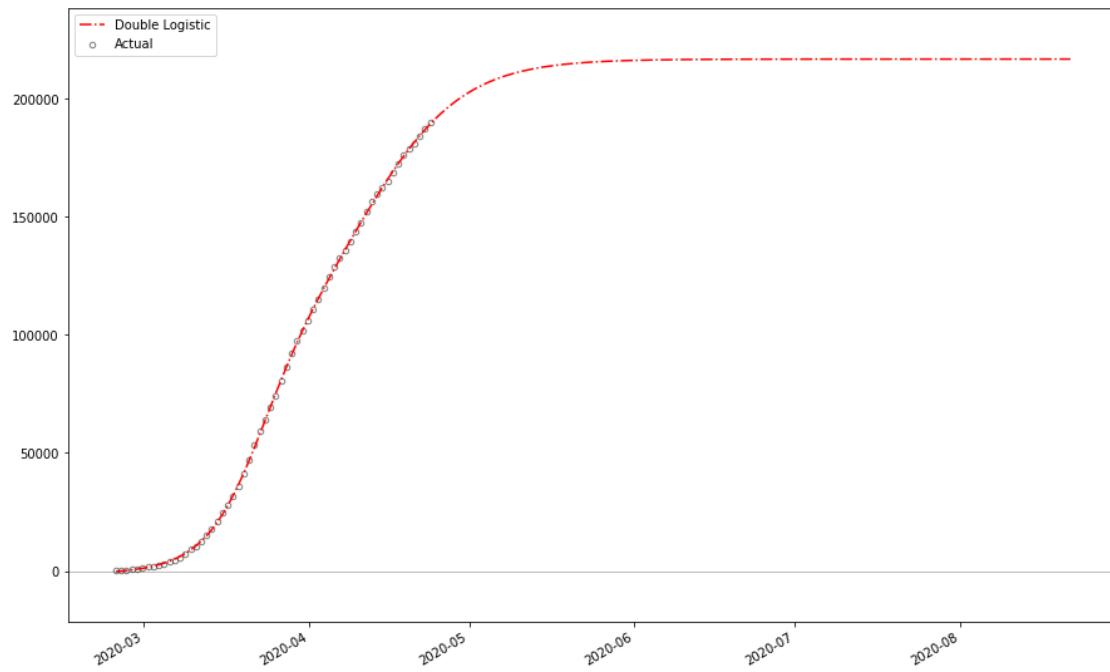
## Italy cases interpolated on double Gompertz curve



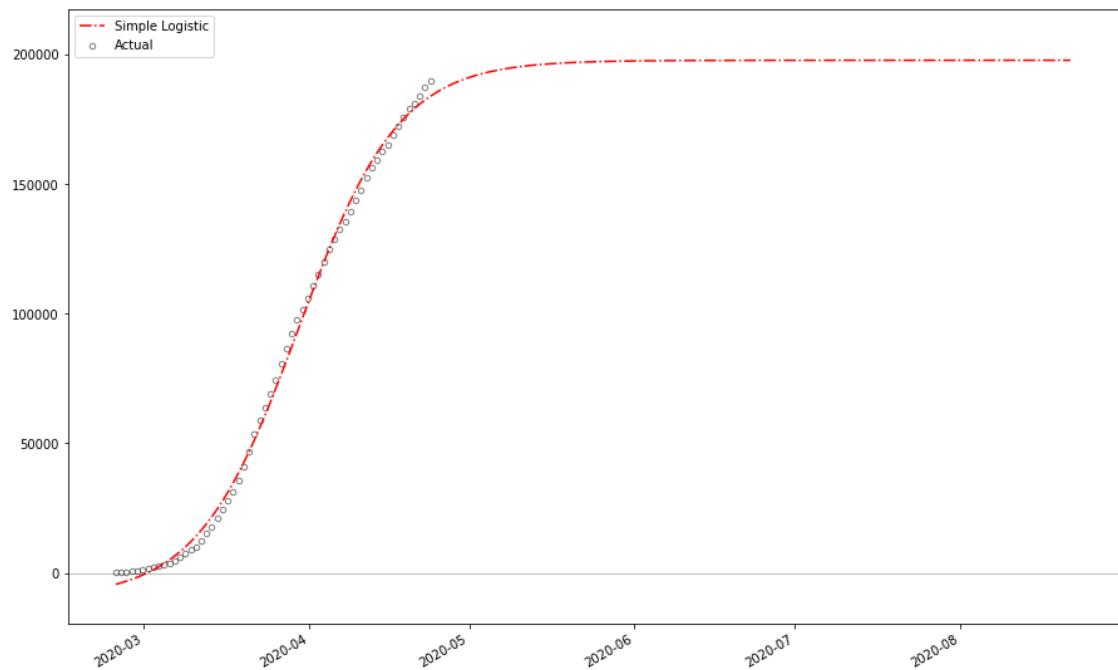
Italy cases interpolated on Double Gompertz



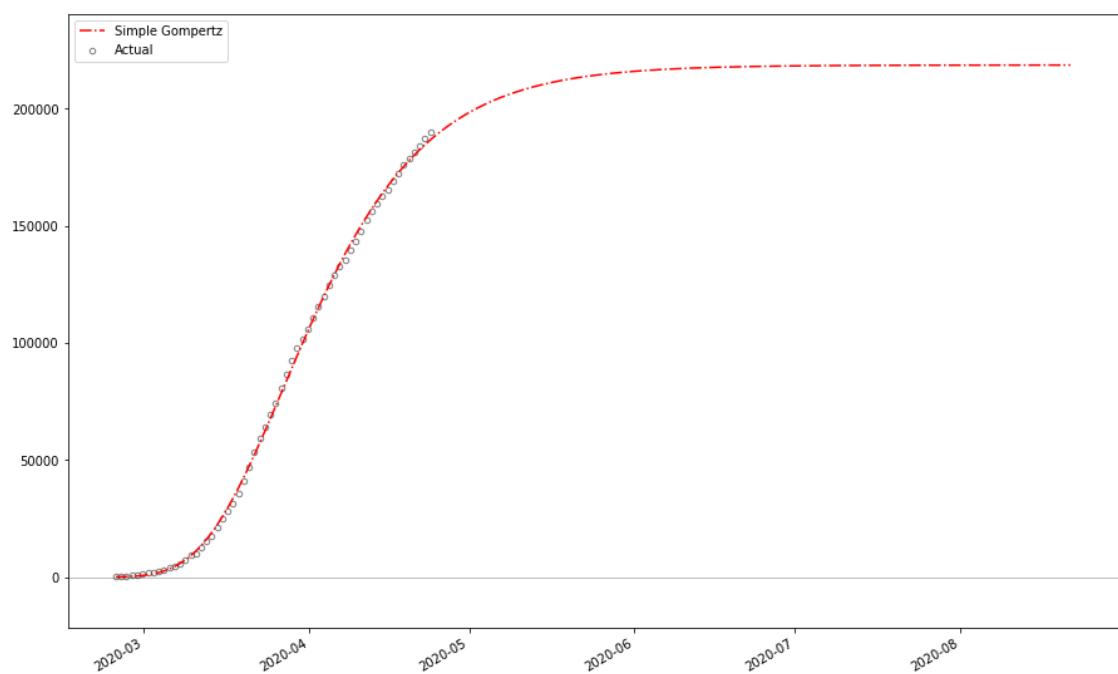
Italy cases interpolated on Double Logistic



Italy cases interpolated on Simple Logistic



Italy cases interpolated on Simple Gompertz



Si decide di: - Considerare arbitrariamente nazioni con più di 100 infetti, al fine avere un minimo base di dati a disposizione - tentare una prima interpolazione sui dati grezzi tutte le nazioni scelte con `curve_fit` con metodo `dogbox` di `scipy` in python su - logistica semplice (Logit) - logistica doppia (DobLog) - Gompertz semplice (Gomp) - Gompertz doppia (DobGomp) - rigettare le interpolazioni fallite per errori del modulo `curve_fit` - Valutare la bontà dell'interpolazione sui dati tramite funzione `linregress` di `scipy`

I dati saranno presi dall'archivio della Johns Hopkins University (ref), raggruppandoli per nazione (ref).

TOTALE NAZIONI: 185  
Compatibile: Afghanistan, INFETTI: 1176  
Compatibile: Albania, INFETTI: 634  
Compatibile: Algeria, INFETTI: 2910  
Compatibile: Andorra, INFETTI: 723  
Non compatibile: Angola, INFETTI: 25 < 100  
Non compatibile: Antigua and Barbuda, INFETTI: 24 < 100  
Compatibile: Argentina, INFETTI: 3144  
Compatibile: Armenia, INFETTI: 1473  
Compatibile: Australia, INFETTI: 6547  
Compatibile: Austria, INFETTI: 14925  
Compatibile: Azerbaijan, INFETTI: 1518  
Non compatibile: Bahamas, INFETTI: 65 < 100  
Compatibile: Bahrain, INFETTI: 2027  
Compatibile: Bangladesh, INFETTI: 3772  
Non compatibile: Barbados, INFETTI: 75 < 100  
Compatibile: Belarus, INFETTI: 7281  
Compatibile: Belgium, INFETTI: 41889  
Non compatibile: Belize, INFETTI: 18 < 100  
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Non compatibile: Bhutan, INFETTI: 6 < 100  
Compatibile: Bolivia, INFETTI: 609  
Compatibile: Bosnia and Herzegovina, INFETTI: 1368  
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Compatibile: Brazil, INFETTI: 45757  
Compatibile: Brunei, INFETTI: 138  
Compatibile: Bulgaria, INFETTI: 1024  
Compatibile: Burkina Faso, INFETTI: 609  
Compatibile: Burma, INFETTI: 123  
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Non compatibile: Cabo Verde, INFETTI: 73 < 100  
Compatibile: Cambodia, INFETTI: 122  
Compatibile: Cameroon, INFETTI: 1163  
Compatibile: Canada, INFETTI: 41648  
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Non compatibile: Chad, INFETTI: 33 < 100

Compatibile: Chile, INFETTI: 11296  
Compatibile: China, INFETTI: 83868  
Compatibile: Colombia, INFETTI: 4356  
Compatibile: Congo (Brazzaville), INFETTI: 186  
Compatibile: Congo (Kinshasa), INFETTI: 359  
Compatibile: Costa Rica, INFETTI: 681  
Compatibile: Cote d'Ivoire, INFETTI: 952  
Compatibile: Croatia, INFETTI: 1950  
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Compatibile: Cyprus, INFETTI: 790  
Compatibile: Czechia, INFETTI: 7132  
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Compatibile: Diamond Princess, INFETTI: 712  
Compatibile: Djibouti, INFETTI: 974  
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Compatibile: Ecuador, INFETTI: 10850  
Compatibile: Egypt, INFETTI: 3659  
Compatibile: El Salvador, INFETTI: 237  
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Non compatibile: Eritrea, INFETTI: 39 < 100  
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Non compatibile: Fiji, INFETTI: 18 < 100  
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Compatibile: France, INFETTI: 159297  
Compatibile: Gabon, INFETTI: 166  
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Non compatibile: Haiti, INFETTI: 62 < 100  
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Compatibile: Iran, INFETTI: 85996  
Compatibile: Iraq, INFETTI: 1631  
Compatibile: Ireland, INFETTI: 16671

Compatibile: Israel, INFETTI: 14498  
Compatibile: Italy, INFETTI: 187327  
Compatibile: Jamaica, INFETTI: 233  
Compatibile: Japan, INFETTI: 11512  
Compatibile: Jordan, INFETTI: 435  
Compatibile: Kazakhstan, INFETTI: 2135  
Compatibile: Kenya, INFETTI: 303  
Compatibile: Korea, South, INFETTI: 10694  
Compatibile: Kosovo, INFETTI: 510  
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Non compatibile: Malawi, INFETTI: 23 < 100  
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Non compatibile: Maldives, INFETTI: 86 < 100  
Compatibile: Mali, INFETTI: 293  
Compatibile: Malta, INFETTI: 444  
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Compatibile: Moldova, INFETTI: 2778  
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Compatibile: New Zealand, INFETTI: 1451  
Non compatibile: Nicaragua, INFETTI: 10 < 100  
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Compatibile: Nigeria, INFETTI: 873  
Compatibile: North Macedonia, INFETTI: 1259  
Compatibile: Norway, INFETTI: 7338  
Compatibile: Oman, INFETTI: 1614  
Compatibile: Pakistan, INFETTI: 10076  
Compatibile: Panama, INFETTI: 4821  
Non compatibile: Papua New Guinea, INFETTI: 8 < 100

Compatibile: Paraguay, INFETTI: 213  
Compatibile: Peru, INFETTI: 19250  
Compatibile: Philippines, INFETTI: 6710  
Compatibile: Poland, INFETTI: 10169  
Compatibile: Portugal, INFETTI: 21982  
Compatibile: Qatar, INFETTI: 7141  
Compatibile: Romania, INFETTI: 9710  
Compatibile: Russia, INFETTI: 57999  
Compatibile: Rwanda, INFETTI: 153  
Non compatibile: Saint Kitts and Nevis, INFETTI: 15 < 100  
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Non compatibile: Saint Vincent and the Grenadines, INFETTI: 13 < 100  
Compatibile: San Marino, INFETTI: 488  
Non compatibile: Sao Tome and Principe, INFETTI: 4 < 100  
Compatibile: Saudi Arabia, INFETTI: 12772  
Compatibile: Senegal, INFETTI: 442  
Compatibile: Serbia, INFETTI: 6630  
Non compatibile: Seychelles, INFETTI: 11 < 100  
Non compatibile: Sierra Leone, INFETTI: 61 < 100  
Compatibile: Singapore, INFETTI: 10141  
Compatibile: Slovakia, INFETTI: 1244  
Compatibile: Slovenia, INFETTI: 1353  
Compatibile: Somalia, INFETTI: 286  
Compatibile: South Africa, INFETTI: 3635  
Non compatibile: South Sudan, INFETTI: 4 < 100  
Compatibile: Spain, INFETTI: 208389  
Compatibile: Sri Lanka, INFETTI: 330  
Compatibile: Sudan, INFETTI: 140  
Non compatibile: Suriname, INFETTI: 10 < 100  
Compatibile: Sweden, INFETTI: 16004  
Compatibile: Switzerland, INFETTI: 28268  
Non compatibile: Syria, INFETTI: 42 < 100  
Compatibile: Taiwan\*, INFETTI: 426  
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Compatibile: Thailand, INFETTI: 2826  
Non compatibile: Timor-Leste, INFETTI: 23 < 100  
Non compatibile: Togo, INFETTI: 88 < 100  
Compatibile: Trinidad and Tobago, INFETTI: 115  
Compatibile: Tunisia, INFETTI: 909  
Compatibile: Turkey, INFETTI: 98674  
Compatibile: US, INFETTI: 839675  
Non compatibile: Uganda, INFETTI: 63 < 100  
Compatibile: Ukraine, INFETTI: 6592  
Compatibile: United Arab Emirates, INFETTI: 8238  
Compatibile: United Kingdom, INFETTI: 134638  
Compatibile: Uruguay, INFETTI: 543  
Compatibile: Uzbekistan, INFETTI: 1716  
Compatibile: Venezuela, INFETTI: 288

Compatibile: Vietnam, INFETTI: 268  
Compatibile: West Bank and Gaza, INFETTI: 474  
Non compatibile: Western Sahara, INFETTI: 6 < 100  
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Non compatibile: Zambia, INFETTI: 74 < 100  
Non compatibile: Zimbabwe, INFETTI: 28 < 100  
ACCETTATE 132 NAZIONI

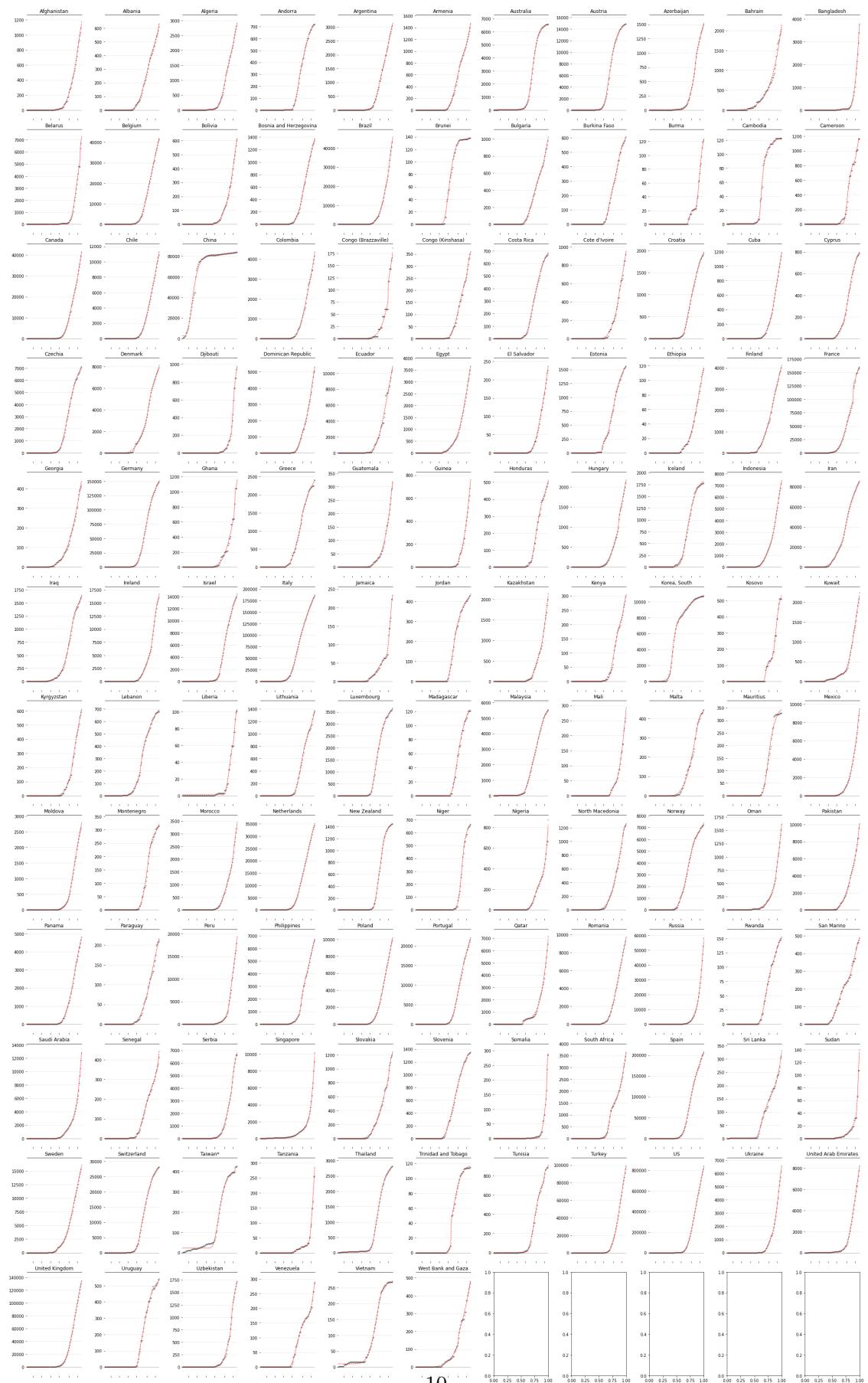
## 2 Interpolazione di Gompertz Doppia

NAZIONI PROCESSATE: 132

NAZIONI PROCESSATE CORRETTAMENTE: 127

NAZIONI CON ERRORI: 5

NAZIONI FINALI: 127



country	slope	intercept	r value	p value	std' err
Afghanistan	0.999260936482703	-0.1069842203518838	0.999615938253908	2.591246760351023e-143	0.0028207332379076174
Albania	0.9994781471891167	-0.294917990225510948	0.9995008946913241	7.655000013240652e-137	0.0033298538333635726
Algeria	0.99880404534375	0.53814073380833	0.99956462415618	5.100000013240652e-136	0.00323394223886672
Angola	0.99939404534375	-0.0383113738408934	0.99978632759345	1.550860317982745e-135	0.00323394223886672
Argentina	0.9993990056879554	0.5063157621177345	0.9997556873496946	8.418504921811438e-151	0.00232908368783900146
Armenia	0.9986451738056717	0.5734851891227208	0.999475871245723	6.914680463043282e-136	0.0034095315664411
Australia	0.999772117871379	0.2793295479361859	0.9998623055395650	5.247371852139932e-162	0.0017490345701401421
Austria	0.999492309547655	2.30426797242505	0.999760478905365	3.4529710322268636e-151	0.0023063388146019317
Azerbaijan	0.99956801940709	0.0688086453836855	0.999912024106668	5.010319464106668e-158	0.0033617313144341772
Bahrain	0.9995485385139	0.3481148071451	0.99991408713111	1.170000013240652e-153	0.0033617313144341772
Bangladesh	0.99943765163716	-0.1711828567122839	0.9998484246878702	1.1363969613991297e-159	0.0018575109931905959
Belarus	0.981058390567561	0.3500907695107495	0.999500864692494	2.4053951099196312943	0.004582176466767385
Belgium	0.999724166433325	2.0202435803657863	0.999857962137391	2.121844668875975e-161	0.00176319482750486
Bolivia	0.9993696419608863	-0.0769021130875702	0.999460459818346	2.5582256066305932e-135	0.003462017600109576
Bosnia and Herzegovina	0.999450260467863	0.2947123817053563	0.9998243548977365	2.998765273315041e-157	0.0019374832020121126
Brazil	0.999521521521	0.3641148071451	0.99991408713111	1.770000013240652e-153	0.0033617313144341772
Bulgaria	0.9995771138393265	0.3500907695107495	0.9991099196312943	2.4053951099196312943	0.004582176466767385
Burkina Faso	0.999810219181249	-0.1042517036344748	0.999797390186505	1.857662975835147e-154	0.002122059404007197
Burma	0.9979614308959592	0.12794567065694196	0.999817519462861	6.778313459572619e-156	0.002045561731560029
Cambodia	0.99693667335595238	0.0394760075344107	0.99803933592064922	1.83065869045033286e-121	0.004930569968226358
Cameroon	0.998403777294377	0.10498068457656586	0.9974263496394282	8.32967398211463e-105	0.0075738160440187
Canada	0.999521521521	0.3641148071451	0.99991408713111	1.770000013240652e-153	0.0033617313144341772
Chile	0.9990063205748049	0.22880326731979525	0.9997147971474825	5.90828069331094e-149	0.0024423640464832762
Czechia	0.99958266564039	0.6553361704399686	0.999789703280643	8.959857656377136e-154	0.00216121901528345
Denmark	0.999272882120297	1.35887125354154	0.999607562949244	1.53447919150543861161	0.009291690543861161
Djibouti	0.999521521521	0.3641148071451	0.99991408713111	1.770000013240652e-153	0.0033617313144341772
Dominican Republic	0.999521520863162	0.3003131576951757	0.9997578372432397	4.785926782789376e-151	0.000731479128636617
Ecuador	0.998211907783562	12.63693840342421	0.9964094104889655	4.62320515977485e-98	0.00889233033343564
Egypt	0.9997647548146018	0.1139974442981177	0.999878652335069	1.7791400273959771785043	0.001641899045305808
El Salvador	0.99930749131067275	0.02002487142645748	0.999675750556301	3.381549040557916e-144	0.002756574811006911
Estonia	0.9987315588650606	0.0733480897081317	0.999595061050749	6.5848415615938959e-139	0.003155960205146342
Ethiopia	0.999521521521	0.3641148071451	0.99991408713111	1.770000013240652e-153	0.0033617313144341772
Finland	0.999521520863162	0.6039845422738923	0.999545139418783	2.0311363655927013e-139	0.00311303903878482
France	0.9991389532563184	24.60005988228238	0.999986336395869	2.44223230341253536e-141	0.0029850178565544935
Georgia	0.99746636221751381	0.1860960223869045	0.9986240273237892	7.847456694473141e-118	0.005409233210731749
Germany	0.9998547573251263	0.507468084886155	0.999962402176141	2.9744520686517596e-174	0.001278597517785043
Ghana	0.9990342563030419	0.9694071162614919	0.996492510732597	1.915247798684877992e-99	0.0087904248577992
Greece	0.999102487585776	0.5751753392464912	0.99991887598285179	1.4804957965661636e-137	0.00326383384303041
Guatemala	0.999521521521	0.3641148071451	0.99991408713111	1.770000013240652e-153	0.0033617313144341772
Guinea	0.9992074975344745	0.04817691523977495	0.999624810914563	2.6101887299705656e-151	0.0029859545987792945
Honduras	0.998369709302035	-0.060215015896190494	0.999305663318103	8.01367630422206e-131	0.00379321791458832
Hungary	0.999427193683878	0.6242407064143413	0.99972298792010272	1.16972102135203271e-128	0.004102354130702262
Iceland	0.9998468332202533	0.850930726176388	0.9992412020308001	4.61819013168356e-183	0.00102059729204893
Iran	0.99973110381620297	0.507468084886155	0.99991408713111	1.7161923230456e-126	0.0033617313144341772
Iraq	0.999521520863162	0.350673123303772	0.9997480907403451	2.832327559074037e-159	0.0003692322305740487
Ireland	0.999765731652063	0.556462265677926	0.9998732051528836	7.283632709754132e-163	0.016733553398717376
Israel	0.9995688321648497	1.25425529109290946	0.999788728637336	1.2070489145622392e-153	0.005958418534268
Italy	0.998694303056871	6.31053829169503	0.999309425169503	2.178099720109703e-176	0.00121069071241034
Jamaica	0.99912918291490808	0.2679467905547651	0.9964740560532115	1.1597686638011235e-98	0.0088060424372034
Jordan	0.9990124971791790143	0.6061162574601564	0.99991408713111	0.003010790605673264	0.003010790605673264
Kazakhstan	0.999521521521	0.3641148071451	0.99991408713111	1.770000013240652e-153	0.0033617313144341772
Korea, North	0.9997148239903235	0.1876141939413962	0.9997706501993329	3.171901836053121e-119	0.00521700986660539
Kosovo	0.9946732264339214	7.62852512461814	0.995795773781238	1.612723159923528e-150	0.0024365202054596767
Kuwait	0.998445754827626	0.560440367878122	0.9995737742802686	2.110479497275754e-105	0.0074221590628198875
Kyrgyzstan	0.9991637368224464	-0.10930079112706228	0.99982491720824398	8.117598520070717e-130	0.003985134451954285
Lebanon	1.0000331315208209	0.2679467905547651	0.99964740560532115	1.434957643675323e-152	0.0033617313144341772
Liberia	0.999521521521	0.3641148071451	0.99991408713111	1.770000013240652e-153	0.0033617313144341772
Lithuania	0.99903718080012	0.49895735239948385	0.999628125965563	1.36238427779139856e-142	0.002872779175181814
Luxembourg	0.9996749726116533	0.3606881360378579	0.999588407801263	1.846027311274102e-161	0.0017734852651410831
Madagascar	0.9986897136856778	0.0669595134186349	0.999686220654325	7.85909203501101e-127	0.0042998021038525
Malaysia	0.99857233024804981	0.0446110381603803	0.999300991363560347	6.9311251809202169e-163	0.001466838901598498
Mali	0.999773113422	0.04526603699533	0.99991304166652916	5.3806754598643586e-126	0.003887481373737
Mauritius	0.999755789032937	-0.0841789035786864	0.99974809324698703	7.128768892711256e-108	0.009935354666048345
Mexico	0.998362245405862	0.485208562381566	0.99989353724281914	2.2693265947542096e-167	0.001524618804134069
Moldova	0.9991755822113317	-0.25505559804855693	0.99982827399273e-157	0.001983672959473097	
Montenegro	0.9970069059749263	2.22761169762381248	0.998064231685685	1.61419761261566e-121	0.0049189565882642
Morocco	0.999558450428862	0.3485007855238946	0.9998134551948608	3.0998538281543703	0.0020356389137287
Netherlands	0.9988214395769579	1.417261783374356	0.99991408713111	7.95975668281543703	0.003649811159343703
New Zealand	0.999521521521	0.3641148071451	0.99991408713111	1.770000013240652e-153	0.0033617313144341772
Niger	0.9997591033737174	-0.26805922500731316	0.999653042531309	6.072864512596892e-144	0.0027168387979443092
Nigeria	0.996332599138795	0.576889363081122	0.99804359904931934	3.948340416762661114	0.005591410861316532
North Macedonia	0.9989901701713131	0.1810223112997562	0.9997897073117142	0.53003671710086935	0.002102059729204893
Norway	0.9996201795534513	0.70233513159522	0.9997897073117142	7.549210160601445e-154	0.0021609474420699114
Oman	0.999063310802933	0.0481137671671974	0.99980401169663835	4.15229552608842683e-155	0.002086826882131926
Pakistan	0.9994404124952405	0.404923207058343	0.999733928263239	2.4701612615232755e-148	0.0033617313144341772
Paraguay	0.99527545987473356	0.299797047197494	0.9988226929365876	1.006255796701630375	0.002273050664851786
Peru	0.999323800438865	1.338362970504972	0.999664210016363	5.201091181734265e-144	0.002258679572439474
Philippines	0.9995253407857954	0.605199266253942	0.9997708893204	3.27059957646002606e-158	0.00192647991800051463
Poland	0.99965340942999	0.5931232724762363	0.999870828893204	3.27059957646002606e-158	0.00192647991800051463
Portugal	0.9986866742337356	1.276211887337835	0.9998445309941304	4.2881745984233742356	0.000507840427549486669
Qatar	0.999521521521	0.3641148071451	0.99991408713111	1.770000013240652e-153	0.0033617313144341772
Romania	0.999657077313739	0.21474477115900738	0.999866931561923	9.711184409385918e-163	0.0017446404909765795
Russia	0.9999011520334501	0.405210140381314	0.9994847839848843	3.226532719309836e-181	0.0106940494982388888
Rwanda	0.9983894445981481	-0.067816561123561	0.999499086001619	1.8549227097827436e-136	0.00335913604511463
San Marino	0.9997249416375757	0.2686307374022021	0.99883400063378	2.6378945340933485e-120	0.005078494804796669
Saudi Arabia	0.999642514449086	0.491471263824519407	0.999		

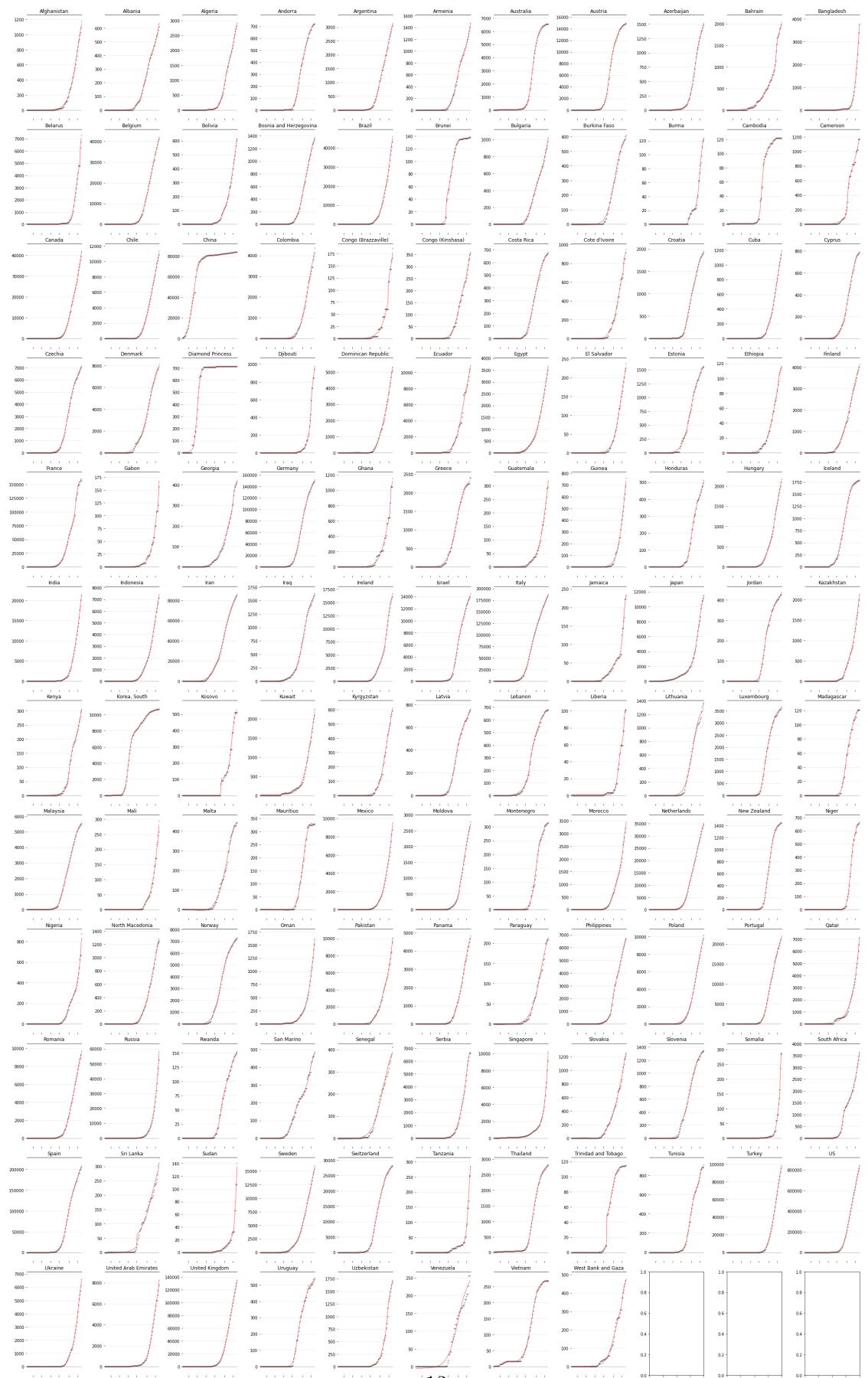
TOTAL nations 127  
TOTAL samples per nation: 92  
TOTAL samples: 11684

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Mean Slope: 0.998413  
Mean Intercept: 3.852683  
Mean R: 0.999223  
Mean P: 9.22E-91  
Mean Std Err: 0.003519

### 3 Interpolazione su Logistica Doppia

NAZIONI PROCESSATE: 132  
NAZIONI PROCESSATE CORRETTAMENTE: 129  
NAZIONI CON ERRORI: 3  
NAZIONI FINALI: 129



country	slope	intercept	r value	p value	std err
Afghanistan	0.9986412490825034	0.2570536705781876	0.999255583531562	4.958869147394618e-129	0.00406406981539833
Albania	0.9991387607547503	0.0911581010620921	0.9995648420612784	1.6032657205303768e-139	0.00310806929944777
Algeria	0.999523412381237	0.354834229880113	0.999576856268161	6.903224450500151e-151	0.00232420568142228
Angola	0.999681230477147	0.05678623531082	0.999583352355789	2.00993745233557e-152	0.00232420568142228
Argentina	0.9994488121873045	0.3583023666874477	0.9997601125324403	3.6987940267018726e-151	0.002308002242417527
Armenia	0.9993348957018593	0.11473291249370732	0.9995830852428125	2.334490524305852e-140	0.003042735914368334
Australia	0.999873905848441	0.3284612645524445	0.999943941121643	1.4042453011452959e-179	0.001160408333201375
Austria	0.99987975854061182	0.4649287000165714	0.9999356515389868	7.13802737856769e-177	0.001195754895148448
Azerbaijan	0.9996505522771564	0.2952727483052695	0.999826906062692	1.552501083050695e-157	0.0019608240101652
Bahrain	0.9999100000000001	0.5131600000000001	0.9999999999999999	2.222222222222222e-151	0.003999999999999999
Bangladesh	0.999628759318759	0.06765371349877114	0.9998410234540478	3.576477087251413678e-159	0.0018791680394767912
Belarus	0.99848882345692909	1.1424218526481124	0.999926652078212351	2.3470413083951168e-129	0.001040034362709359
Belgium	0.9994827051546186	0.402101425529872	0.9997415103495958	1.065339997033376e-149	0.002399933801019918
Bolivia	0.9984328955045951	0.2091716024195449	0.9999546178798876	1.0605597371242252e-138	0.0031717786584164512
Bosnia and Herzegovina	0.999688534342727	0.05083307185183511	0.9998186210083899	1.272568335543734576e-156	0.00107294240561397
Brazil	0.9999100000000001	0.7875000000000001	0.9999999999999999	1.0000000000000001e-152	0.003999999999999999
Bruce	0.9980829200939001	0.2704805795795705	0.9999675322067097	3.0360132515292858e-145	0.0026816338118129502
Bulgaria	0.9993483493361927	0.03781345561433784	0.9999617239719337	4.95148871824316e-142	0.000915760964433773
Burkina Faso	0.9966859167518685	0.3476927007821189	0.99830453631214183	5.168544038536916e-113	0.00612506655094085
Burma	0.99820873313440015	0.07948397294667586	0.99835771199660149	6.73241650402351e-116	0.005696486665650391
Cambodia	0.997356379669295	0.159641561085337	0.998326039192468	5.274974150363779e-122	0.004860738140487666
Cameroon	0.997371801591584	0.3059817806220565	0.998687525350047	5.91267178202741e-118	0.005391680214004464
Canada	0.9999100000000001	0.516306015273306	0.999987947292869	1.0000000000000001e-153	0.001696613298438588
Chile	0.99973087691731939	0.0516306015273306	0.999987947292869	3.4091418395687756e-163	0.001696613298438588
China	0.99637517190381981	0.23726120797496095	0.9998186128710741	1.2310963620828547e-111	0.0063344850732467095
Colombia	0.9997725786925281	0.150986232287424	0.9988723228742701	6.420585139957486e-121	0.0049989514613596476
Congo (Brazzaville)	0.9991154750909243	0.12794105221111241	0.9952519095131489	7.39412508871142375e-93	0.010217521433080141
Congo (Kinshasa)	0.99923591705786361	0.0369714745819523	0.9999136130398575	4.606179343428046e-126	0.0043878217389294245
Costa Rica	0.9999100000000001	0.3097164561085337	0.9999999999999999	1.0000000000000001e-102	0.002399999999999999
Cote d'Ivoire	0.9979704945434233	0.311754970870556	0.999843195781501	1.6533578657134687e-114	0.00389883702444177
Croatia	0.9988251957842988	0.02505089161908196	0.9999313569626915	4.160408915608997e-171	0.001385775551834633
Cuba	0.9998764157996126	-0.055348990374122024	0.99997949318445661	3.1876128472646583e-154	0.0021347940482384694
Cyprus	0.9991602838528353	0.2271252686967418	0.99967150246032538	4.619436101010626e-145	0.00269704246032538
Czechia	0.999577852903162	0.6147504834266606	0.999796204395797	2.409011464528090e-154	0.00212765749498931
Denmark	0.9981085343859866	3.4169870948486764	0.9999504513488934	2.3556255543662968e-124	0.0017915086639561
Diamond Princess	0.9999100000000001	0.3097164561085337	0.9999999999999999	1.0000000000000001e-150	0.003999999999999999
Djibouti	0.998452201139812	0.1460343249411531	0.9999863735651717	2.99184620840453629	0.0004040850667831976
Dominican Republic	0.99893293509883998	0.8641304942424313	0.99984947907120524	3.1447368680925963e-136	0.0033807446617336085
Ecuador	0.9993190074846668	12.028740931166794	0.9996592755373198	4.2911955618039616e-99	0.008664463637944522
Egypt	0.9995793638097454	0.27528377250143876	0.99997673949781601	1.842438124535646e-151	0.00229048991193255
El Salvador	0.9977689407916216	0.028133889590662875	0.99896894484305869	5.91267178202741e-121	0.004945160981536375
Eswatini	0.9999100000000001	0.2278134567693058	0.9999999999999999	1.40407178202741e-157	0.00196006464614298
Ethiopia	0.999986601731723	0.00937453744666982	0.99994595087234793	1.924987311385260766e-135	0.0034568602785461217
Finland	0.9990210913466096	0.774205608242383	0.9999498033999298	9.261585199303e-137	0.006333735673085491
France	0.9988897152026347	34.150167228336045	0.999944237078305	9.65600732035542e-135	0.003511859652193785
Gabon	0.9993657052285939	0.070916456460111	0.997121968259009	1.2657398673091641e-102	0.007963689348610634
Georgia	0.9993088620179158	0.031983530289594	0.99954479387518378	6.9849480712454766e-139	0.0024387821738929425
Germany	0.9997867640832209	0.5606142321192165	0.9999840337374937	0.0000000000000001e-167	0.0035343373731348162
Ghana	0.9999100000000001	0.3097164561085337	0.9999999999999999	1.0000000000000001e-109	0.003999999999999999
Greece	0.99940057041362679	0.6359805588486412	0.9999488863088847	9.70580343486553e-137	0.00333407898681258
Guatemala	0.9980153266363372	0.03508891726358337	0.998711354718032778	1.9249896504938073e-118	0.005328243281361164
Guinea	0.99743352711547668	0.14665921613682542	0.999479171340761	5.20337796672327146e-136	0.00339897878380313
Honduras	0.998707524947667667	0.146465921613682542	0.99949713074663556	0.0039196265149196933	0.0039196265149196933
Hungary	0.998578137631335	0.15155498067305568	0.99993073744873352	1.929087256249789e-130	0.002322179607299885
Iceland	0.999688534342727	0.029998172635836	0.9999999999999999	1.0000000000000001e-159	0.003999999999999999
India	0.9998686373793897	0.771303924748707	0.999837704690498	2.0608747487486e-156	0.003999999999999999
Indonesia	0.9999030525954672	0.1318364413491514	0.99994665301531878	1.550203931199299e-180	0.001080747352952927
Iran	0.99873137132957203	22.987913136286403	0.99994883483572459	2.778731176823554e-136	0.003736345165508695
Iraq	0.9993739219973555	0.275076802652625	0.9999671670879396	5.0122986275024594e-145	0.002700122177540348
Ireland	0.9996416703832487	0.874267286197058	0.999822073282975	5.35987322619888e-157	0.00388000118016606
Israel	0.9996407109738112	0.2278134567693058	0.99982597139062896	1.924989571390237e-157	0.002278134567693058
Italy	0.9999100000000001	0.2278134567693058	0.9999999999999999	1.0000000000000001e-150	0.003999999999999999
Jamaica	0.998185203516536	0.354048275151223	0.99986118327216111	8.6940618303161e-97	0.0023975781024031
Japan	0.9907701510425707	1.7419805795795704	0.9999352093508151881	4.0310923119687575e-138	0.00322179607299885
Jordan	0.9995317527145091	-0.10931244035864474	0.99953199893161361	1.2657398673091641e-102	0.0032245253341480703
Kazakhstan	0.9989731957803243	0.0319835302895879	0.9999544613491514	3.050044167087378e-137	0.0032995355357708823
Kenya	0.99830726106126966	0.011530421945208218	0.9995340655502092	8.363808173134348e-132	0.00378410051622323
Korea, South	0.998968749090053665	0.209086730049388	0.9999492090624683	1.049241780930490e-109	0.003999999999999999
Korea, North	0.9999100000000001	0.209086730049388	0.9999999999999999	1.0000000000000001e-150	0.003999999999999999
Kuwait	0.99921764379325	0.120975152712724	0.9998102343067023	9.3159171915793578e-113	0.00647838631435202
Kyrgyzstan	0.9985042068373999	0.14623861135135017	0.99990723470654362	1.3094137158223945e-124	0.0045397815714877
Latvia	0.999524892849532	0.03275067874994875	0.999813553231593	5.70386728491581e-153	0.0022035773373880
Lebanon	0.9991181345134103	0.1873845146022157	0.999905897135849154	1.834968914851464e-141	0.0029573262361136895
Liberia	0.9991625998080442	0.475485171375358	0.999708460277825	3.078665243249842706	0.00272424910210041
Lithuania	0.9999100000000001	0.209086730049388	0.9999999999999999	1.0000000000000001e-152	0.003999999999999999
Luxembourg	0.99945216926157688	0.5600546185794378	0.9999740500746728	8.8509610903224799e-150	0.003999526353450152
Madagascar	0.9970743379309542	0.14192061859218234	0.9998126479263474	5.895645217290541e-126	0.004390739668632025
Malaysia	0.999761644597854	0.3390687063074981	0.999989978543485186	0.00151056759822132	0.00151056759822132
Mali	0.9969901177098324	0.2467228662061553	0.999922149040169	1.045583432296376e-123	0.00465006252539887545
Malta	0.99786513898966502	0.9980634011541212	0.9999871890523966	0.00045802484256124	0.00176104996028876e-123
Mauritius	0.999786521689899	0.305383130251267975	0.9999871897107865	2.036578901582238437	0.00168980823039374
Mexico	0.9999100000000001	0.3097164561085337	0.9999999999999999	1.0000000000000001e-150	0.003999999999999999
Moldova	0.9997865809069593	0.06113457116940525	0.999955152744761655	1.814385752744761655	0.001735044744710842
Montenegro	0.9980071051280516	-0.130165441349153	0.9998611737853291	0.00160436436539686e-129	

TOTAL nations 129  
TOTAL samples per nation: 92  
TOTAL samples: 11868

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Mean Slope: 0.998028  
Mean Intercept: 3.149797  
Mean R: 0.999045  
Mean P: 6.96E-76  
Mean Std Err: 0.003819

#### 4 Interpolazione su Logistica semplice

NAZIONI PROCESSATE: 132  
NAZIONI PROCESSATE CORRETTAMENTE: 132  
NAZIONI CON ERRORI: 0  
NAZIONI FINALI: 132



country	slope	intercept	r value	p value	std err
Afghanistan	0.9986412490825034	0.2570536707817876	0.9992555853531562	4.95869147394618e-129	0.00406496815938933
Albania	0.996582589952987	0.4371081370236863	0.9983156758368982	4.39914695370936e-113	0.0061047622384503
Algeria	0.9963914218025024	1.8251953180886744	0.9982050332732804	7.596256881902036e-112	0.00630503442054511
Andorra	0.996964900681115	0.3835350237136232	0.9985948044683615	2.2990570079794381e-109	0.00585951522667
Argentina	0.9970011380000001	0.3893000000000001	0.9981152567650285	2.8890000000000002e-103	0.00709145359230406
Armenia	0.9944702162205059	1.59737463747617542	0.99791162556782058	4.348852748747031e-103	0.00709145359230406
Australia	0.9996584723617001	0.97852873481680891	0.9998091638594138	1.2528717053049059e-155	0.002095188814439306926
Austria	0.998704156116212	5.343388339480043	0.9993527457517377	9.342186853634262e-132	0.0037026740748065965
Azerbaijan	0.9993270779418814	0.3795932795505428	0.999754284391297045	1.1045234792795405e-150	0.002335957638963524
Bahrain	0.99605870989874041	3.159324232963615	0.9995280606998010	5.63224347726679e-93	0.0101812793571651
Bangladesh	0.9993518557307404	0.1074866515745476	0.999703970809738	0.0025797843742201247	
Barbados	0.9981491900000001	3.3000000000000001	0.9995000000000001	1.8250000000000002e-100	0.0000000000000000
Belgium	0.9982092533164004	1.330130770579911	0.9991052753973918	1.92702986694293e-125	0.0044592616061174978
Bolivia	0.9983089803400995	0.1762160487978747	0.999163207319444	5.49755140587373e-127	0.0043073674356094759
Bosnia and Herzegovina	0.9986335645929378	0.397177059476648	0.9993948215995312	4.46002966033201e-133	0.003663885886318001
Brazil	0.9987471671707806	7.58738914391897	0.9997346719866882	1.945231945820305e-123	0.0037248465839073
Brunei	0.99781560989626955	0.2686145785206405	0.998110231887175	7.74466153662625e-111	0.006642170305338375
Bulgaria	0.993242866733778	0.3039000000000001	0.9994520454561361	0.0000000000000000	0.0000000000000000
Burkina Faso	0.99859317675105	0.4746973000000001	0.999348036312353	5.1626500000000002e-103	0.0000000000000000
Burma	0.9987976162721508	0.0602040003076920	0.994766679374879	3.530413535625371104e-141	0.011199957146236141
Cambodia	0.998216811813556	-0.063373800536965	0.997538267618902467	1.1293343453636652e-105	0.00739677621915823
Cameroon	0.988242128457568	2.321126970140398	0.9993219297623267	4.8142228273870526e-88	0.01113789862882305
Canada	0.997210435188013	17.795795380387463	0.9986603432299833	3.68527169621266e-117	0.005595302705017577
Chile	0.998156802582035	3.206771798549615	0.999161348780609	1.050013106240123e-126	0.00431234571965525
China	0.995680007772597	28.750642216200024	0.9987004322885771	0.0000000000000000	0.0000000000000000
Colombia	0.9981675750000001	1.5300000000000001	0.9992000000000001	4.2200000000000002e-101	0.00325163581359347
Congo (Brazzaville)	0.981061882676779	0.50937156136267839	0.9998218456376718	4.60669701034246e-100	0.01019316994707329
Congo (Kinshasa)	0.994326452982838	0.3272456801440124	0.997178779804879	0.0000000000000000	0.00788984499573757
Costa Rica	0.9979357923818187	0.287966199805833	0.9989018553424299	1.947042099839071e-116	0.004938238360782999
Cote d'Ivoire	0.9956962351593567	0.76526717913515	0.9978958267618128	9.4884310309309e-109	0.0068194241704098
Croatia	0.997657117269092	1.078151343207611	0.998860786379871	1.0151921504958272e-101	0.00502939956012031
Cuba	0.9981447000000001	0.349447342747464	0.9995808400000001	3.0000000000000002e-100	0.0000000000000000
Cyprus	0.9989715380190000	0.1493263288500000	0.9978030213235688	5.1578050601	0.0000000000000000
Czechia	0.998248788315015	0.88032618564951	0.99940753944617744	1.70179977486137e-133	0.003625684637536599
Denmark	0.9980904059052763	3.617785352783507	0.9990032165567017	4.214335750652000e-123	0.004070495855348133
Diamond Princess	0.997465172945238	1.2863465398475675	0.9988504259824546	1.525375398519061e-120	0.0050467464716493221
Djibouti	0.9952671978458889	0.2872300574916028	0.9975935720036208	1.10263390132087268e-100	0.007372260000000000
Dominican Republic	0.9970518311027277	3.2376842976064248	0.9985199759965623	1.312715253921774e-115	0.005724390865340875
Ecuador	0.9981000000000001	0.2880000000000001	0.9994520000000001	0.0000000000000000	0.0000000000000000
Egypt	0.998404651773342	0.75880117277871	0.999758429780208	5.03491747279050e-151	0.00231601324821441
El Salvador	0.9977689470916216	0.02831389596062875	0.998864344838569	2.48717971974052e-121	0.0049451650953613675
Estonia	0.9977546951721232	0.8504244856572008	0.999801300089579	1.95701666102477e-121	0.00493321496539244
Ethiopia	0.996298869317013	1.908151784735925	0.9992939176921946	3.40940803443936e-130	0.00394881744542565
Finland	0.9981515662850235	0.278112635062035	0.999100954295295	2.41143061825326125	0.00464711781372085
France	0.995490449296743	1.3880342022707282	0.9977427121650397	2.922207076804563e-107	0.007062533921705715
Gabon	0.9984770000000001	0.3000000000000001	0.9993000000000001	0.0000000000000000	0.0000000000000000
Georgia	0.997487117273342	0.1409531145495277	0.998863575034108	3.68653570264977e-121	0.004647889487461214
Germany	0.9983778515312418	0.362325276152568	0.999488635384646	2.72358335646467e-136	0.003368105176403208
Ghana	0.98904570079133	0.7588117277871	0.999758429780208	0.000013377109968e-89	0.01105027067582764
Iraq	0.9970045700000001	0.4125595160500143	0.998860760239876	9.17085834865453e-137	0.003349887986481258
Ireland	0.9978589399999999	0.3099880000000001	0.9993488635800000	3.0998800000000002	0.0000000000000000
Israel	0.9970781495979701	8.5841492636197629	0.998523445129451629	0.027968605150279e-116	0.005705091712068745
Italy	0.9977048686997951	11.3637128371971815	0.99885153530106207	1.460346972133436e-120	0.00504464416816283595
Jamaica	0.9977104615606405	0.64683508130617	0.99876634559321591	4.375747718502616e-76	0.015571403761762846
Japan	0.9953669626505305	8.84796174042409	0.9976764250808689	5.41935189792484e-107	0.01764948570934761
Jordan	0.9953957087981081	0.6429431517323671	0.9978740646105051	1.5307971939695674e-108	0.00651776615971595
Kazakhstan	0.9966352380000001	0.9383221656235	0.9993221656235	3.6999800000000002	0.0000000000000000
Kenya	0.998471157071734	0.3000000000000001	0.9994988635800000	3.0000000000000002	0.0000000000000000
Korea, South	0.9886731904204643	59.921363840530573	0.9943163670670431	2.73127908118913e-89	0.0115985238461946
Kosovo	0.9858677581094909	1.134201503323893	0.99924098067663070	3.9570136362232568e-85	0.0124173990164637
Kuwait	0.9961228842335356	1.306199082330898	0.998070461698934	1.1701424591593e-110	0.006529553318360415
Kyrgyzstan	0.99717997039540832	0.369402452163452	0.9998945402778507	3.697923842726e-123	0.0049719730537755
Latvia	0.99805015090139026	0.3525737847671766	0.99898501503565795	3.73998123447077e-121	0.004970414983268465
Lebanon	0.9979334896674474	0.4037017313240313	0.9988248515998913	4.10381383199876e-122	0.005171403821360203
Lithuania	0.9949321570779449	1.3497140461657585	0.9974458203079718	5.922791138601656e-105	0.0070151353424406
Luxembourg	0.9973886691974568	2.504741172420697	0.998732266983278	1.206645913047853e-118	0.00598686511667636
Madagascar	0.99846285963666693	-0.0638543355815054	0.9986165917977792	3.21288406774423e-111	0.0034959032551570236
Malaysia	0.9982531837652271	2.342519526561113	0.999143951951832	4.2603613622502e-126	0.00437970261361674
Mali	0.9978338525163017	-0.02608654777977924	0.998407040425454	4.58446647294915e-101	0.0050500000000000
Malta	0.9970781495978363	0.4380000000000001	0.9993488635800000	3.0000000000000002	0.0000000000000000
Macedonia	0.9974544878385364	0.3540380289916768	0.998063524034204	2.13071520468361e-115	0.0057813918995146
Mexico	0.999695865861665	0.867346116674435	0.99966150507757753	9.7437605158703e-142	0.002973481595331631
Moldova	0.992464611976645	0.2963613095174651	0.999635035635415345	3.3424002553206863e-143	0.002828785856827102
Montenegro	0.997505284734940833	0.18286014450446245	0.9986220389535488	0.0000000000000000	0.0052555919162836283
Morocco	0.9986892473370379	1.4287944449094406	0.9984369703103515	1.1527115895434574e-114	0.00588211961947317
Netherlands	0.9981758832756977	1.861561963605963	0.9990890530089079	4.350913459683905e-125	0.00449140993456274
New Zealand	0.9974000000000001	0.2789039425732009	0.9995200770893744	0.0000000000000000	0.0000000000000000
Niger	0.986150628517334	1.3551603171198471	0.99323246837157558	5.88900777588808e-86	0.012153481988261873
North Macedonia	0.9979971913081388	0.4673736652092126	0.9988602015210512	1.042153572245752e-101	0.005026178603008686
Norway	0.9989081917914455	2.24708310272122	0.9949595574893675	2.7413902547893675e-135	0.003460817359355915
Oman	0.9987087197373379	1.6949842489947126	0.9993594724784074	2.741395692189067e-132	0.00376997039541876
Pakistan	0.9964160731221511	0.54594953651666662	0.9980526187242454	0.0000000000000000	0.0000000000000000
Panama	0.9981000000000001	0.3670000000000001	0.9993471722557000	1.2067123463243626e-132	0.004000000000000000
Paraguay	0.9952215661109888	0.193259594412426	0.997285725569484	4.85718616624921104	0.007740709812077775
Peru	0.99836585190973	3.466795487927906	0.999185376904924	1.707486779384013e-127	0.004492749378198959
Philippines	0.99509505225727647	5.0624530553497874	0.9997506255686785	2.97510627742163e-109	0.006731721179015976
Poland	0.998805258104202543	2.08913617768703	0.9994005300724561	2.69369627452054e-133	0.003633495335203295
Portugal	0.9972313769461683	8.87142224175149	0.9998634547643758	1.45125368238465e-122	0.00479136485953193
Qatar	0.9969453452722272	2.32039424574587	0.9993744354593800	3.0000000000000002	0.0000000000000000
Romania	0.9982613744556227	0.3099853473200000	0.9993583595383333	1.1000000000000002	0.0000000000000000
Russia	0.9999176527731813	0.1883385222320000	0.999748222545127268	5.0571656224035598e-101	0.0067631437129543
Singapore	0.997122335356	3.2043942457389	0.9999212542117600	5.0571656224035598e-101	0.0067631437129543
Slovakia	0.9957051589626276	0.96685780806561	0.999726235245127268	5.0571656224035598e-101	0.0067631437129543
Slovenia	0.9980248022882592	0.322925579446176	0.9990		

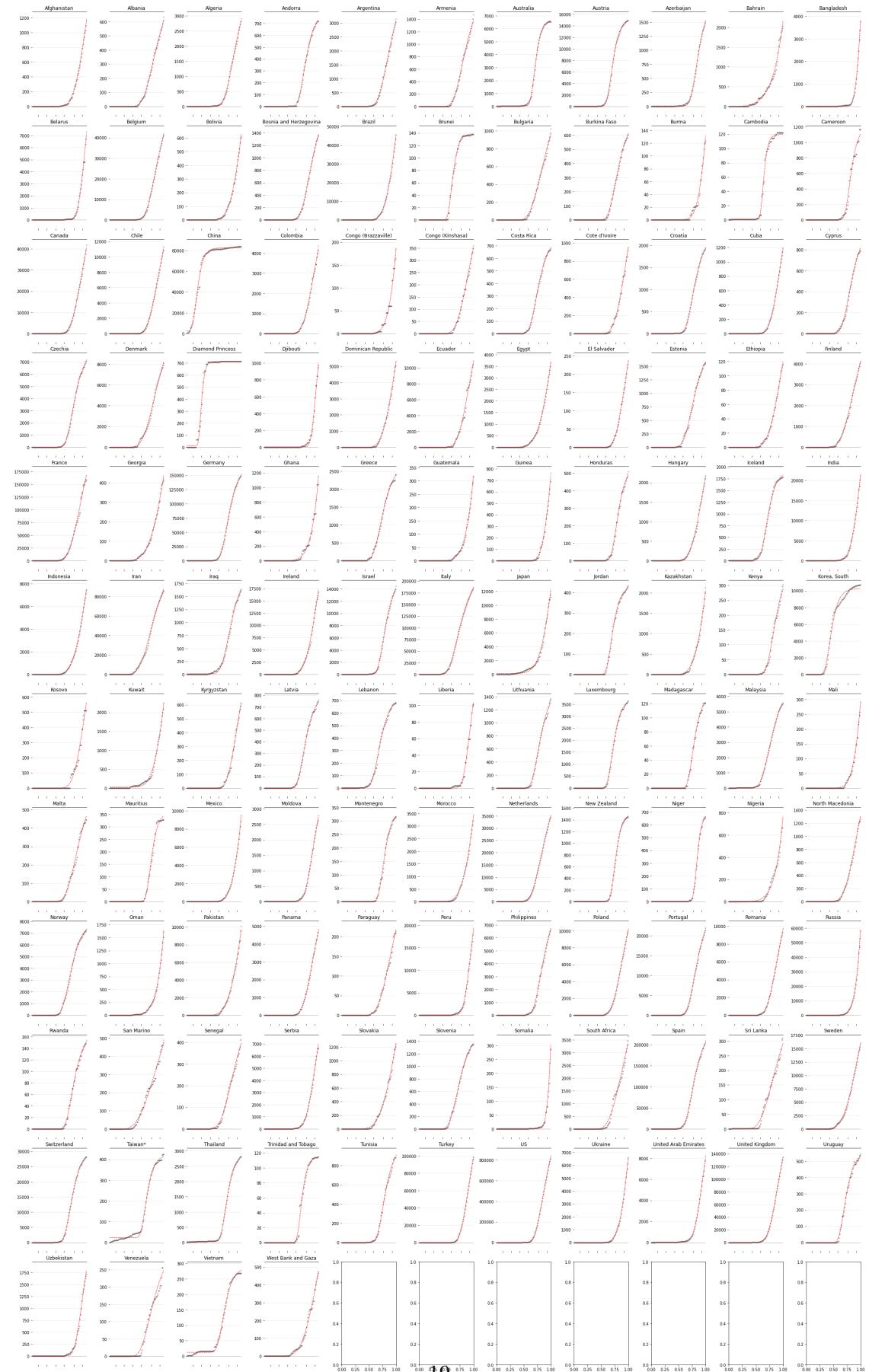
TOTAL nations 132  
TOTAL samples per nation: 92  
TOTAL samples: 12144

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Mean Slope: 0.995687  
Mean Intercept: 9.419208  
Mean R: 0.997833  
Mean P: 7.27E-76  
Mean Std Err: 0.006152

## 5 Interpolazione su Gompertz semplice

NAZIONI PROCESSATE: 132  
**NAZIONI PROCESSATE CORRETTAMENTE: 125**  
**NAZIONI CON ERRORI: 7**  
NAZIONI FINALI: 125





TOTAL nations 125  
 TOTAL samples per nation: 92  
 TOTAL samples: 11500  
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Mean Slope: 0.996940  
 Mean Intercept: 6.581740  
 Mean R: 0.998444  
 Mean P: 4.68E-82  
 Mean Std Err: 0.005059

## 6 Comparazione funzioni

Function	Nations	Days	Samples	Slope	Intercept	Rho	p-value	Std Err
Double Gompertz	127	92	11684	0.9984132344750873	3.852682853843071	0.999227646756108	9.21878483473776e-91	0.003518706363078977
Double Logistic	129	92	11868	0.9980277427940518	3.1497969222186226	0.999045400246561	6.9597698001e-76	0.003813095137290701
Logistic Simple	132	92	12144	0.99566711715226	9.419207697585285	0.9978331056031308	7.277042895367207e-76	0.006151713101754049
Gompertz Simple	125	92	11500	0.9969396432496366	6.5817401762238275	0.998444303257768	4.680060090632159e-82	0.005059486991333803