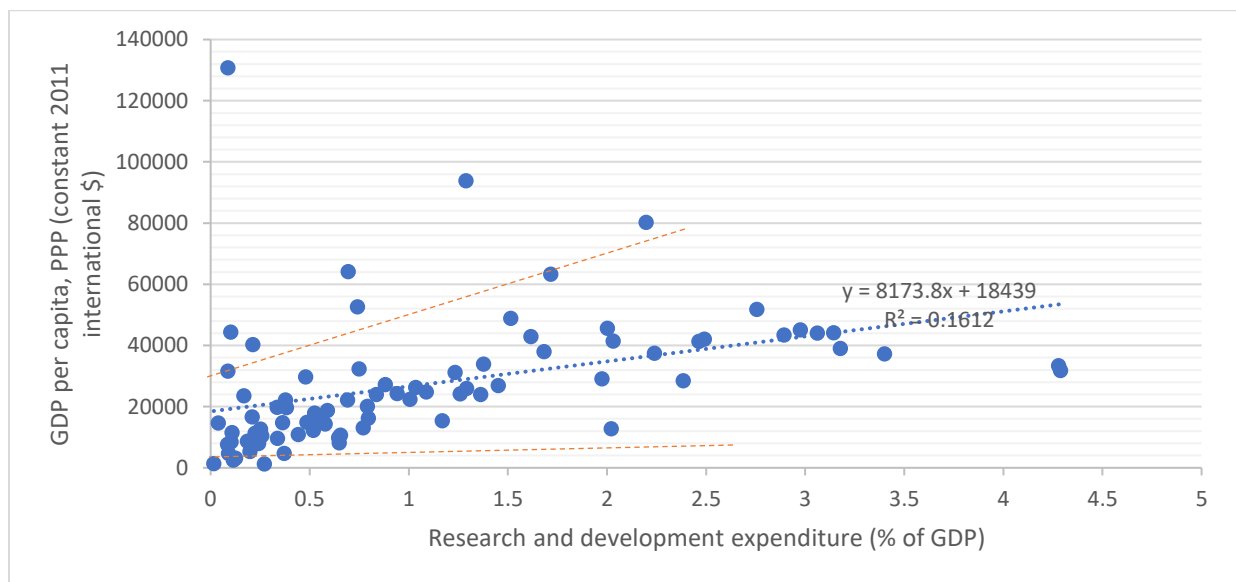


Question: “Countries that invest more in information technology would achieve consistently higher productivity and income growth rate.” How would you verify this hypothesis? What are the caveat of this hypothesis?

Innovation and growth

From many studies, innovation is an important growth driver. It strongly supported by “Endogenous growth theory” claimed that investment in human capital, innovation, and knowledge are significant contributors to economic growth. Moreover, innovation is the critical economy changer where innovation create new product and destroying the existing one, namely, “creative destruction”. Then entrepreneur gain market power leading to the profitability opportunity to reap benefit from old product.

Figure 1: plot GDP per capita and Research and development expenditure (% of GDP)



Source: World Development Indicator (Databank, 2017)

The positive relationship between innovation and income is supported by figure (1). It shows the expenditure on research and development per GDP which is the main proxy affect the innovation rate has positive correlation with income per capita and vice versa. Still, there are some robustness of the result showing that some country invests a lot in research and development but do not climb up to high income level. So, this paper will clarify other factors influence the return on innovation to be a caveat before investing in innovation.

What is innovation?

Innovation defines as the introduction of something new which can be categorized into incremental innovation and radical innovation.¹

1. *Incremental Innovation* is a series of small improvements or upgrades made to existing products, services, processes or methods, for example, the development of business model of existing product.
2. *Radical Innovation* is when a new product, service, process or strategy is introduced to a market, but is designed to make a significant impact by completely replacing existing technologies and methods, for example, digital camera replacing film camera.

To avoid misunderstanding, innovation in this paper does not specifically refer to creating new technology but generally refer to the application of better solution to meet new need or obtain better productivity.

Why more investment in innovation does not ensure certain higher growth?

Firstly, because of structural effect of each country, country with different GDP per capita likely to have different endowment. First assumption, private sector in high income country may have excess fund to invest in innovation. In already developed country, they may gain competitive advantage in the existing market where they have market power to charge price over the marginal cost. Therefore, they have positive profit or have extra money to invest in research and development. Second assumption, because country is rich enough and government can get enough tax to support investment in innovation. In conclusion, innovation and growth may have simultaneous correlation that country is rich enough to invest in innovation not large innovation creates higher growth.

Secondly, size of the innovation investment is matter. Country with large investment in R&D like China or India, even they have smaller R&D investment to GDP, but the volume is so large that can create higher chance of success and higher impact to economy.

Thirdly, the appropriate support response to need of economy influence innovation investment pattern. For example, for low income country, the return on investment in creating new innovative product may low or even negative because investment in innovation is costly and people are not well educated enough to absorb and create spillover effect. According to OECD (2012), the report states the role of innovation in each state of development. For low income country, to adopt and adapt incremental innovation from foreign country maybe the most suitable approach like the adopt of fertilizer to improve productivity of agriculture which incurs less cost comparing to create new formula. In contrast for middle to high income country, in order to maintain long term consistence growth, to produce low value-added product is risky from new low cost of production players. Countries require to develop and create more innovation to acquire niche competency, climb up the ladder in the global value chain in order to be competitive in the world market. In conclusion the different need in each stage implies their cost of investment in the way that to develop in higher stage require more intensity comparing to the early

¹ Retrieved from: <http://searchcio.techtarget.com/definition/incremental-innovation>

development. Therefore, high income country need higher investment in R&D than the low-income country.

Lastly, return on innovation also depends on each country absorption ability which influenced by development of education and the good ecosystem that support innovation based economy growth which is Information and Communication Technologies (ICTs) and institution of the country. (OECD, 2012)

1. Education system

For creating innovation, ability to learn new knowledge is very important, therefore, education at all level plays a significance role. Primary and secondary education level help building absorptive ability in local business while training specialist could help creating new innovation. This differences in educational endowment led countries perform divergently.

Support by table (1), there is differences between participation of education for each income level country, high income country has higher participation in both secondary where determine the level of technological adoption and tertiary education where it support creation of technology. Show that the different in return from innovation investment may be a result from higher educational endowment from high investment in education in high income country.

Table 1 shows the education participation rate categorized by country income level.²

	GDP per capita, PPP (current international \$)	Government expenditure on education, total (% of government expenditure)	School enrollment , tertiary (% gross)	School enrollment, secondary (% gross)	School enrollment, primary (% gross)	Researchers in R&D (per million people)	Research and development expenditure (% of GDP)
High income	44585	12.53	73.66	106.35	102.29	4143.52	2.49
Upper middle income	15565	..	44.34	94.23	105.47	1223.60	1.44
Lower middle income	6137	..	23.08	67.86	104.18	..	..
Low income	1589	18.22	7.60	39.26	102.83	..	..

Source: Source: World Development Indicator (Databank, 2017)

2. Information and communication technologies (ICTs)

The development of ICTs help reducing the cost of accessing or diffusing information. The development of ICTs is not only benefit scientist to accumulate information to do research but also offer an opportunity to broaden group of innovators. Therefore, the prevalence of internet user, free access to information sharing system such as YouTube, Google and other site promote the access of information for commons.

3. Institution

Last but not least, the development of innovation required institution. Since innovation is a public goods. After creating, anyone can use. However, investment in R&D is costly and

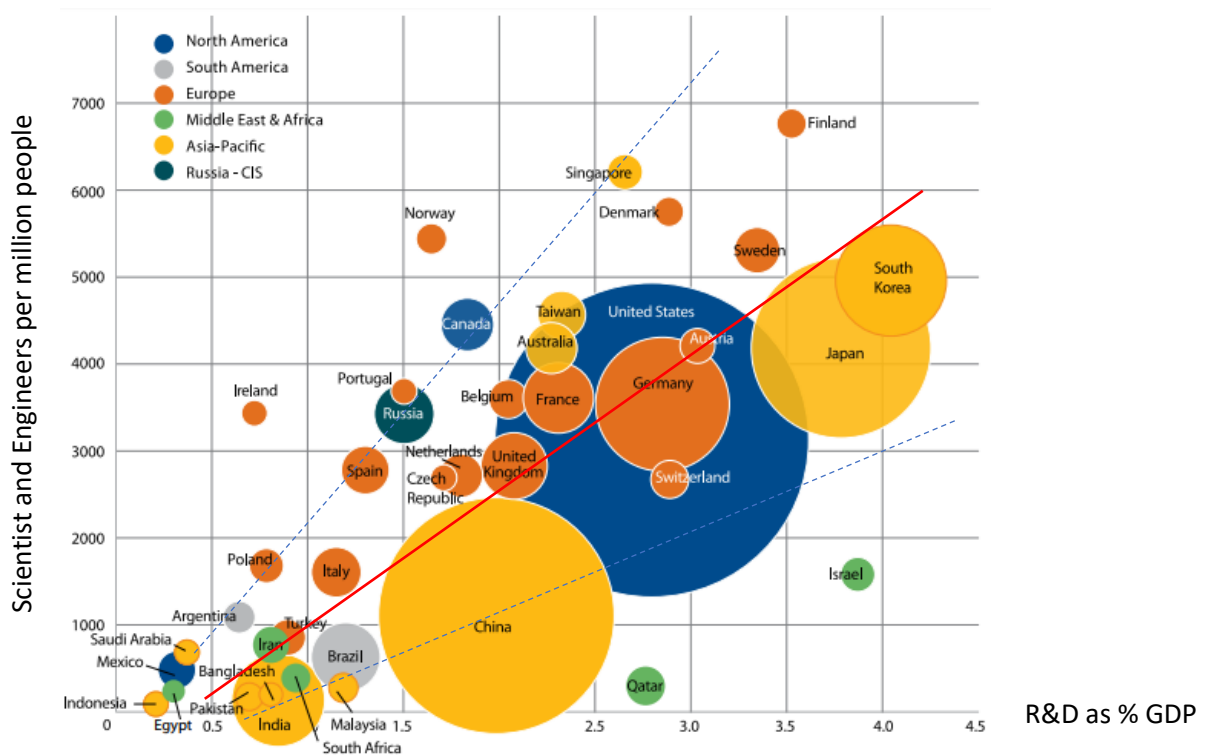
² Full data in table 2 in the appendix

does not ensure the successfulness of owner for example the patent help protect owner's right over new invention. Therefore, it is necessary to have public intervention creating strong institution to protect the benefit of the creator, or else, the inventor may be discouraged from making loss.

Conclusion

In conclusion, because just intensity of investment does not confirm its return. Innovation has to deal with appropriate investment and ability to absorb technology from other country. Thus, we could see variation of innovation investment pattern and return on investment in each country. Supporting with Table 1 and figure 2, it is unsurprising that high-income country who has both higher investment in R&D and more number of scientist and engineer which support the absorption of new technology as well as promote the creation of innovation further.

Figure 2: plot relationship between Scientist and Engineers per million people and R&D as % of GDP across countries. ³



Source: IRI, R&D Magazine, International Monetary Fund, World Bank, CIA Fact Book, OECD

³ Size of the circles reflects the relative amount of annual R&D spending by the indicated country. Note the regional grouping of countries by the color of the balls.

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Appendix

Table 2

<i>Country Name</i>	<i>GDP per capita, PPP (current international \$)</i>	<i>Government expenditure on education, total (% of government expenditure)</i>	<i>School enrollment, tertiary (% gross)</i>	<i>School enrollment, secondary (% gross)</i>	<i>School enrollment, primary (% gross)</i>	<i>Researchers in R&D (per million people)</i>	<i>Research and development expenditure (% of GDP)</i>
<i>Macao SAR, China</i>	137737	13.39	69.36	96.06	96.72	1053.41	0.09
<i>Qatar</i>	127313	12.74	13.48	83.80	99.35	..	..
<i>Brunei Darussalam</i>	80152	9.99	31.73	99.12	107.44	..	..
<i>Norway</i>	65655	..	76.78	112.60	100.14	5679.33	1.72
<i>Switzerland</i>	61228	15.53	57.23	99.77	103.23	..	..
<i>Hong Kong SAR, China</i>	55515	17.62	68.78	100.63	..	3297.56	0.74
<i>United States</i>	54599	14.55	86.66	97.56	99.53	4231.99	2.75
<i>Saudi Arabia</i>	52626	..	61.11	108.29	108.72	..	..
<i>Ireland</i>	51266	..	77.63	127.20	102.12	4433.47	1.51
<i>Austria</i>	48616	10.48	80.00	99.30	102.25	4883.86	3.06
<i>Denmark</i>	47806	..	81.52	129.87	101.33	7333.05	2.98
<i>Germany</i>	47058	11.14	65.47	102.43	103.33	4363.78	2.89
<i>Bahrain</i>	46735	7.94	41.31	98.89	99.68	361.99	0.10
<i>Australia</i>	46446	13.90	90.31	137.56	106.08	..	..
<i>Sweden</i>	46405	14.94	62.35	132.91	120.90	6868.11	3.14
<i>Belgium</i>	44795	11.97	73.32	164.81	104.85	4175.88	2.46
<i>Finland</i>	41512	12.32	88.67	145.48	101.43	6985.94	3.18
<i>United Kingdom</i>	40709	13.66	56.48	127.81	108.24	4299.36	1.68
<i>France</i>	40221	..	64.39	110.64	105.36	4168.78	2.24
<i>Euro area</i>	39980	11.56	71.00	111.42	103.73	3572.72	2.14
<i>Japan</i>	39387	9.29	63.36	101.75	101.22	5386.15	3.40

<i>New Zealand</i>	37182	18.05	80.88	117.49	98.63	..	..
<i>Italy</i>	36294	8.01	63.10	102.62	101.54	1976.68	1.38
<i>Israel</i>	34929	14.28	66.18	101.86	104.18	..	4.29
<i>Malta</i>	33854	..	44.69	94.26	101.90	1881.63	0.75
<i>Spain</i>	33658	9.59	89.07	130.16	104.69	2642.37	1.23
<i>Korea, Rep.</i>	33632	..	94.21	98.45	98.97	6899.00	4.28
<i>Czech Republic</i>	32358	..	66.02	105.13	98.87	3418.46	1.97
<i>Slovenia</i>	30995	..	82.93	110.67	99.30	4149.91	2.38
<i>Cyprus</i>	30483	15.53	53.10	99.42	99.15	1048.40	0.48
<i>Slovak Republic</i>	29020	10.16	52.92	91.92	100.98	2718.53	0.88
<i>Portugal</i>	28806	9.89	65.61	116.40	108.51	3667.96	1.29
<i>Estonia</i>	28543	14.26	71.38	110.41	99.26	3284.45	1.45
<i>Lithuania</i>	28179	..	68.53	106.82	102.46	3111.29	1.03
<i>Seychelles</i>	26565	..	6.43	79.15	104.15	..	..
<i>Greece</i>	26431	..	113.87	106.50	97.62	2715.91	0.84
<i>Poland</i>	25707	11.65	68.11	108.10	100.57	2035.78	0.94
<i>Hungary</i>	25494	9.41	53.19	106.98	101.51	2650.58	1.36
<i>Malaysia</i>	25488	19.70	27.60	77.75	102.77	2017.42	1.26
<i>Russian Federation</i>	25477	..	78.65	100.59	98.56	3101.63	1.09
<i>Kazakhstan</i>	24845	..	48.48	105.48	111.35	..	0.17
<i>St. Kitts and Nevis</i>	24737	..	79.10	91.52	83.72	..	..
<i>Latvia</i>	23908	13.96	67.04	115.36	100.41	1884.03	0.69
<i>Turkey</i>	23111	..	86.31	102.54	105.83	1156.51	1.01
<i>Chile</i>	23082	19.89	86.63	100.40	100.53	427.03	0.38
<i>Croatia</i>	21981	..	69.54	99.00	98.87	1437.31	0.79
<i>Uruguay</i>	20886	..	56.34	95.07	108.55	504.16	0.34
<i>Romania</i>	20797	9.24	53.22	94.78	..	921.50	0.38
<i>Argentina</i>	19801	14.72	82.92	106.78	109.99	1202.07	0.59
<i>Mauritius</i>	19231	20.91	38.67	97.94	102.70	..	..
<i>Belarus</i>	18902	12.41	88.86	107.03	98.97	..	0.52
<i>Azerbaijan</i>	17608	7.38	23.16	..	106.06	..	0.21

<i>Bulgaria</i>	17406	..	70.79	100.88	99.08	1833.14	0.79
<i>Mexico</i>	17363	19.07	29.94	90.55	103.39	..	0.54
<i>Iran, Islamic Rep.</i>	17329	19.66	65.96	88.41	109.18	..	..
<i>Botswana</i>	16764	..	25.04	..	107.63	..	..
<i>Brazil</i>	16192	..	49.28	101.95	111.06	..	1.17
<i>Arab World</i>	15911	..	28.17	70.74	97.03	..	..
<i>Thailand</i>	15647	..	52.51	127.73	103.69	974.00	0.48
<i>Costa Rica</i>	15161	23.11	53.04	120.33	110.79	572.98	0.58
<i>Turkmenistan</i>	15098	..	7.98	85.34	89.37	..	..
<i>Lebanon</i>	14212	..	42.77	61.67	94.12	..	..
<i>Algeria</i>	14203	..	34.59	..	118.75	..	..
<i>Serbia</i>	13806	9.10	58.05	94.34	101.13	1830.99	0.77
<i>Macedonia, FYR</i>	13516	..	39.59	78.58	90.41	838.45	0.52
<i>China</i>	13440	..	39.39	94.33	103.92	1113.07	2.02
<i>Colombia</i>	13395	15.84	53.28	98.76	113.75	114.89	0.25
<i>Dominican Republic</i>	13314	..	47.52	78.36	100.65	..	..
<i>South Africa</i>	13127	19.13	19.38	98.82	99.72	..	..
<i>Maldives</i>	12535	10.14	16.23	..	..	..	..
<i>Mongolia</i>	11955	..	64.27	..	101.68	..	0.22
<i>Tunisia</i>	11326	..	34.58	87.63	113.07	1803.21	0.65
<i>Albania</i>	11325	..	62.71	96.43	112.49	..	..
<i>Sri Lanka</i>	11219	10.78	19.29	..	101.27	..	..
<i>St. Lucia</i>	11084	15.30	16.86	86.46	..	..	..
<i>Indonesia</i>	10537	17.67	31.10	82.47	105.74	..	..
<i>Egypt, Arab Rep.</i>	10407	..	31.68	86.10	103.93	681.61	0.65
<i>Georgia</i>	9216	..	39.18	99.43	116.86	1059.62	0.18
<i>Ukraine</i>	8684	13.12	82.31	99.24	103.91	1026.41	0.65
<i>Armenia</i>	8397	9.37	44.25	..	..	..	0.24
<i>El Salvador</i>	8119	16.11	28.85	81.12	112.19	..	0.08
<i>Philippines</i>	6938	..	35.75	..	..	..	..
<i>Cabo Verde</i>	6245	..	22.98	92.58	113.15	..	..

<i>India</i>	5678	..	25.54	74.28	107.92	..	..
<i>Uzbekistan</i>	5658	..	8.57	96.33	100.16	517.51	0.20
<i>Vietnam</i>	5657	..	30.48	..	109.35	..	..
<i>Lao PDR</i>	5407	12.19	17.29	57.24	116.34	..	..
<i>South Asia</i>	5293	12.88	20.84	64.79	109.08	..	..
<i>Moldova</i>	5017	18.77	41.49	87.32	93.06	651.96	0.37
<i>Pakistan</i>	4821	11.30	10.36	41.64	93.56	..	..
<i>Honduras</i>	4457	..	21.18	68.38	109.15	..	..
<i>Sudan</i>	4412	..	16.32	..	..	..	..
<i>Ghana</i>	4075	21.02	15.89	57.94	106.46	..	..
<i>Kyrgyz Republic</i>	3352	16.11	45.92	90.78	107.67	..	0.13
<i>Cote d'Ivoire</i>	3218	21.77	8.68	40.13	89.61	..	..
<i>Bangladesh</i>	3132	..	13.44	..	..	..	..
<i>Cameroon</i>	3059	..	16.01	56.43	113.55	..	..
<i>Sao Tome and Principe</i>	3048	12.32	9.75	76.90	111.74	..	..
<i>West Bank and Gaza</i>	2961	..	44.01	82.24	94.91	..	..
<i>Lesotho</i>	2807	..	9.84	52.17	107.09	..	..
<i>Tajikistan</i>	2682	..	24.47	..	97.35	..	0.11
<i>Nepal</i>	2387	18.28	15.83	66.87	135.23	..	..
<i>Senegal</i>	2339	24.76	10.34	..	80.88	..	..
<i>Chad</i>	2188	..	3.45	..	..	..	..
<i>Afghanistan</i>	1875	14.47	8.66	55.66	111.74	..	..
<i>Uganda</i>	1755	11.70	4.76	..	..	..	..
<i>Rwanda</i>	1702	..	7.57	39.12	133.58	..	..
<i>Comoros</i>	1509	18.91	8.93	60.35	103.17	..	..
<i>Ethiopia</i>	1501	..	8.13	..	100.12	..	..
<i>Madagascar</i>	1445	..	4.78	38.43	146.74	..	0.02
<i>Togo</i>	1386	19.01	10.12	..	125.11	38.17	0.27
<i>Guinea</i>	1276	11.99	10.85	38.82	91.26	..	..
<i>Mozambique</i>	1137	..	5.97	32.09	104.78	..	..
<i>Burundi</i>	846	..	4.97	37.89	127.64	..	..