Chapter 3
Social Infrastructure Demand: A Macro Approach

1. Introduction

In this chapter, we would like to construct an explicit model to estimate and forecast the 'Social Infrastructure Demand in Thailand' up to 2030. We would apply both the database of international institutions as well as those from Thai government's publications. The social infrastructure comprises 1) Education (schools, university and laboratory facility), 2) Healthcare (medical services facility), 3) Low-income housing, and 4) Government service (building and facility) respectively. The model would be an example of how the task can be attempted explicitly and would be a lesson learned by other Asian developing countries.

In this chapter, we report the macro approach in demand estimation applying both the panel data analysis as well as model simulation. The latter is a counterfactual model simulation with A Computable General Equilibrium Model.

2. Panel Regression Model

ADB (2009)[1] has released method of multiple regression model by Fay and Yepes[2] (2003) in the infrastructure, estimation using multiple regression model, The multiple regression model of is based on the least squares method (OLS) with the explanatory variable of infrastructure stock of each country/year as the explanatory variable, per capita income, a ratio of agriculture and manufacturing industry to GDP. Its validity is verified by an F test.

$$\mathrm{IJ}\ (\mathrm{i,t}) = \alpha_0 + \alpha_1\ \mathrm{IJ}(\mathrm{I}, \mathrm{t}-1) + \alpha_2\ \mathrm{y}\ (\mathrm{i,t}) + \alpha_3\ \mathrm{A}(\mathrm{i,t}) + \alpha_4\ \mathrm{M}(\mathrm{i,t}) + \alpha_5\ \mathrm{D}(\mathrm{i}) + \alpha_6\ \mathrm{D}(\mathrm{t}) + \xi(\mathrm{i,t})$$

[1] ADB (2009), Seamless Asia

[2] Fay and Yepes "Investing in infrastructure: what is needed from 2000 to 2010?", World Bank Policy Research Working Paper 3102, July 2003 http://elibrary.worldbank.org/doi/pdf/10.1596/1813-9450-3102

IJ (i,t) = demand for infrastructure stock of type j-th in country i-th at time t;
IJ (i, t-1) = the lagged value of the infrastructure stock,
y (i,t) =income per capita of country i-th;
A(i,t) = share of agriculture value added in GDP of country i-th;
M(i,t) = the share of manufacturing value added in GDP of country i-th,
D(i) = a country fixed effect,
D(t) = a time dummy;
ξ(i,t) = error term.

It is worth a trial to add the population density and the ratio of urbanization (proportion of the urban resident population in the total population) as an explanatory variable to the above regression model to replace the country fixed effect D(i). Furthermore, if we can collect standard price deflator of construction materials and equipment it may be feasible to estimate the monetary value of social infrastructure investment overtime to 2030.

In our study, we have elaborated the ADB model above to for further analysis with a 'panel regression'. Our model has a left-hand variable as gross fixed capital formation $I\ (i,t)$ the need for total investment of the i-th economy over the period of study 1990-2015 for further capital accumulation and growth. It is assumed to be inclusive both of physical and *social investment* which we are interested. The explanatory variables are real GDP, $y\ (i,t)$ representing the *size* of the economy i-th. The urbanization of the i-th economy, $U(i,t)$ in economic development. The level of industrialization of an economy, $M(i,t)$ shown by value-added share of manufacture in total GDP. We may hypothesize also that the trend factor, $D(t)$ represents the level of exogenous shift in technology over time. The stochastic movement around the trend of the residual component or 'disturbance' term$\xi(i,t)$.

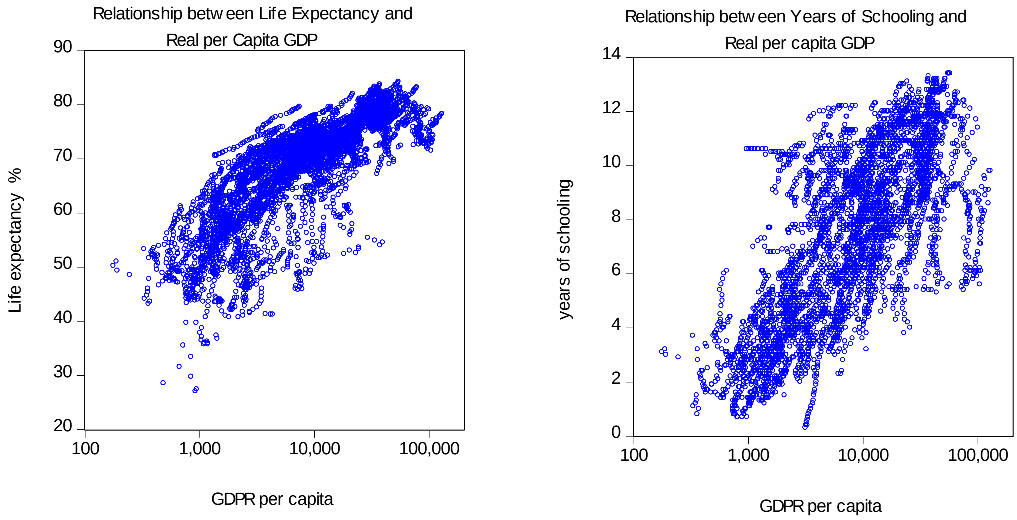
The policy variable $HDI(t)$ non-parametric indices of human capital development. It is a composite index of human capital components and wellbeing of economy i-th. Human Development Index (HDI)[3] emphasizes human ultimate capabilities for assessing the development of a country, not economic growth alone.

The Human Development Index (HDI) is a summary measure of average achievement in critical dimensions of human development: *a long and healthy life, being knowledgeable and have a decent standard of living*. The HDI is, therefore, scores of a composite index of a geometric mean of three normalized indexes.

[3] http://hdr.undp.org/en/content/human-development-index-hdi

The *health* dimension is assessed by life expectancy at birth; the *education* dimension is measured by mean of years of schooling for adults aged 25 years and more and expected years of education for children of school entering the age. The *standard of living* dimension is measured by gross national income per capita. The HDI uses the logarithm of income, to reflect the diminishing importance of income with increasing GNI.

Figure 3.1: Relationship between Human Capital and Real GDP per capita



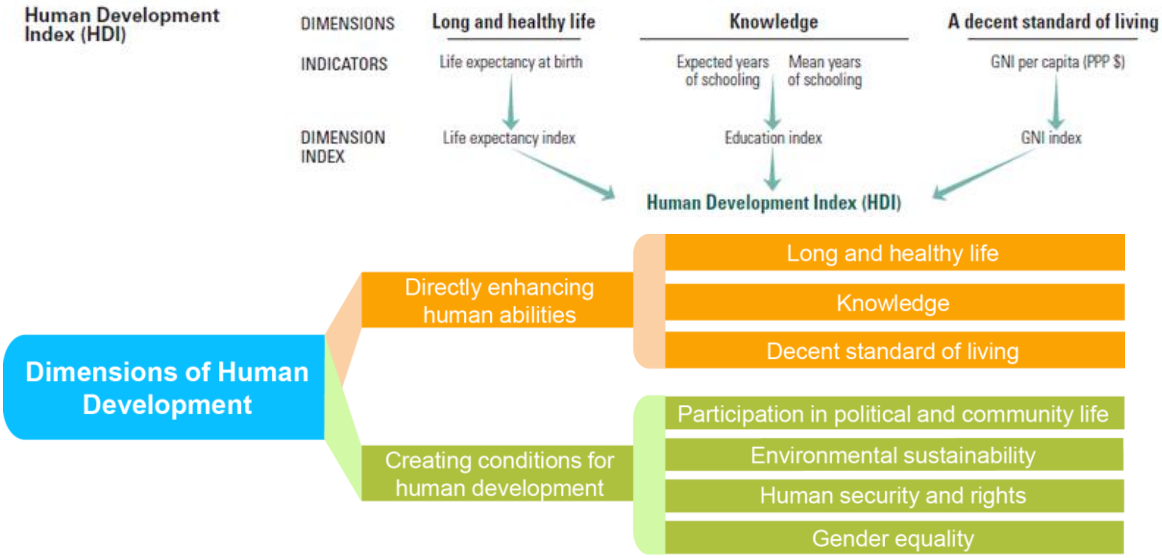
Note: scattered plot with pooling dataset of HDI report

Source: UNDP (2016)

As economic development proceeds, we may postulate that the real per capita income (GDPR) is rising to reflect the well-being of a country. Here, the graphs have shown a positive relationship between income per capita rising and the life expectancy of the population as well as the length of years of schooling for human capital development.

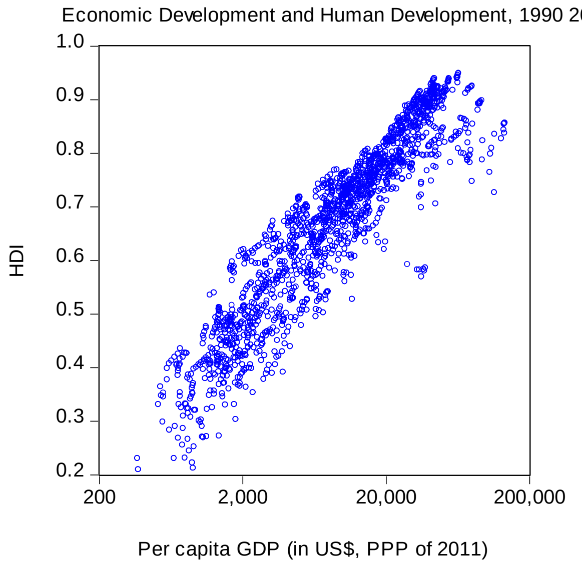
As life expectancy and years of schooling is a component of HDI, we, therefore, plot the epoch of economic development represented by rising per capita income of countries and HDI. They are positively correlated over time and across the level of development.

Figure 3.2: Schematic Presentation of the Dimension of Human Development



Source: UNDP (2016)

Figure 3.3: Relationship between HDI and Real GDP per capita

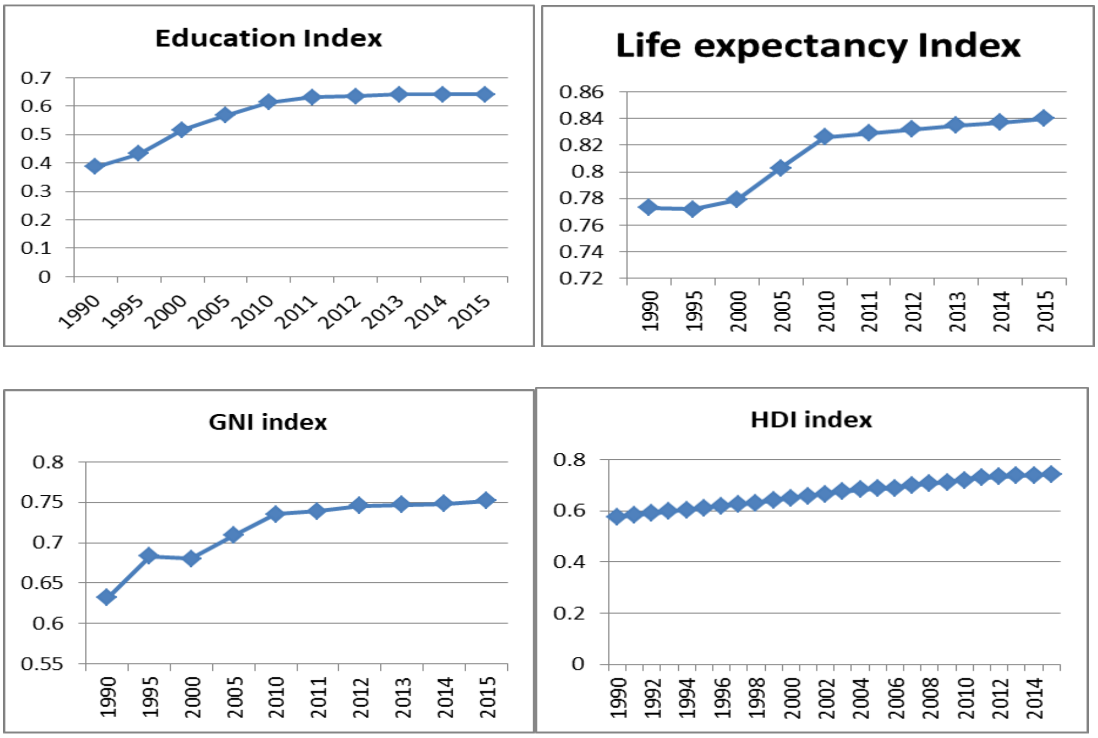


Note: scattered plot with pooling dataset of HDI report

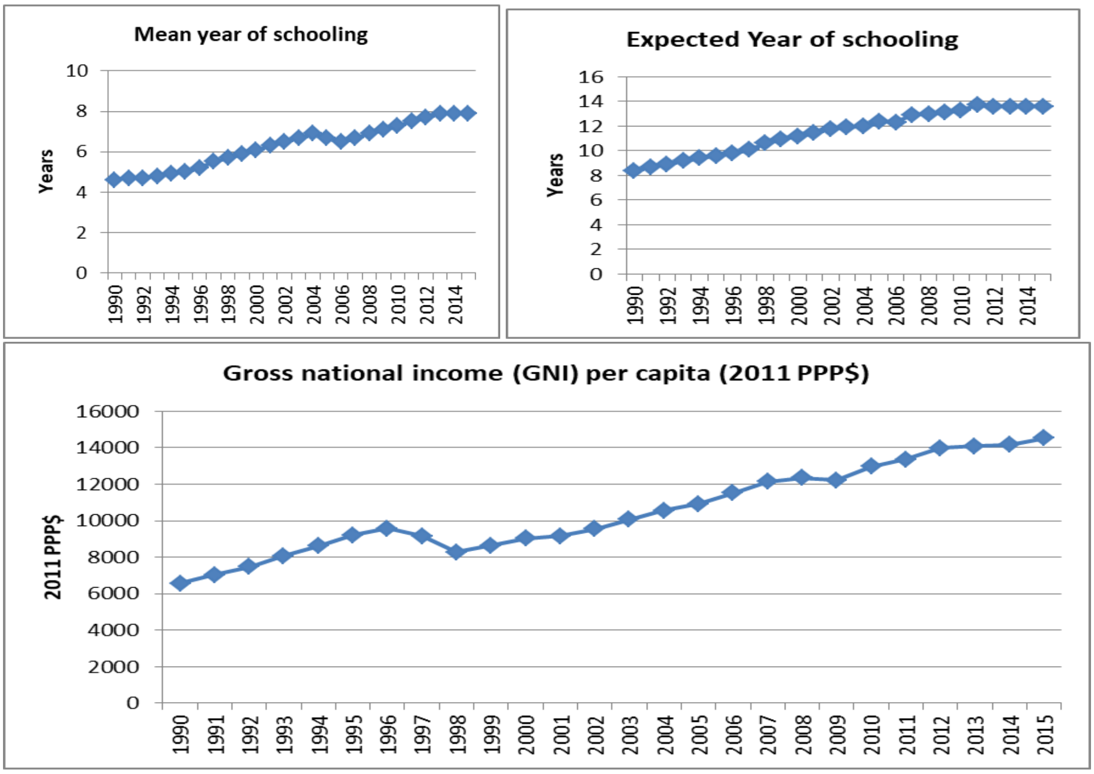
Source: UNDP (2016)

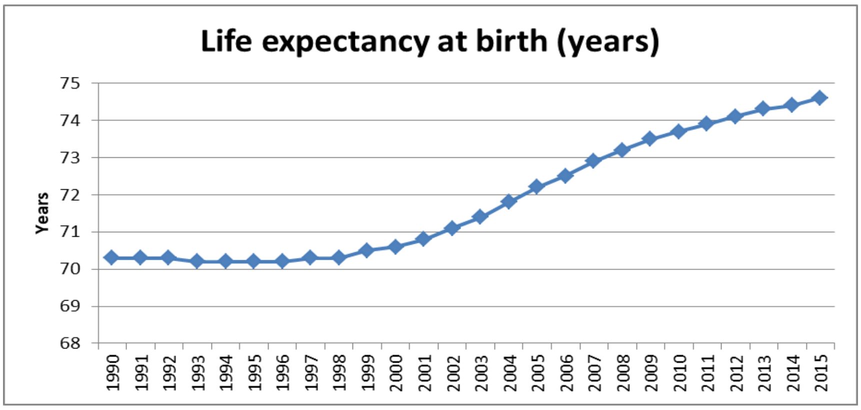
Thus, as any government's policy is to improve country's welfare, they can measure *ex-post* the score of the HDI index. The government has to put her effort, *ex-ante* in the social investment of *human capital* such as lengthen the years of schooling and training in education, improve access to health services to lengthen the life expectancy with healthy lifespan, and to improve the urban welfare.

Figure 3.4: HDI index and components of Thailand



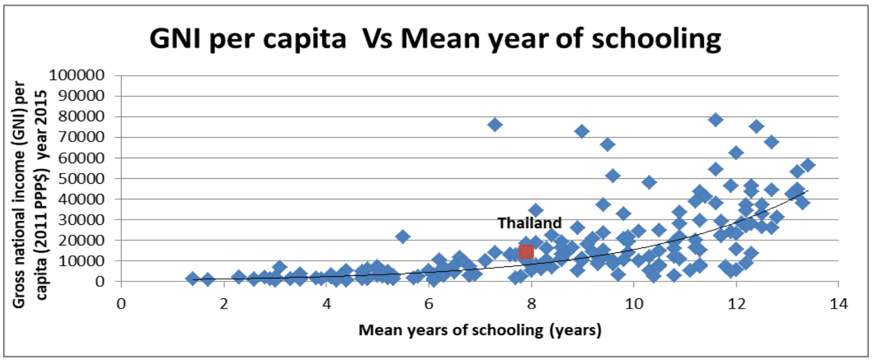
The Graphic for HDI component are as follows:





It should be noted also that the relationship between HDI component such as 'Mean years of schooling' for Thailand has positive relationship with the rising per capita income as well.

Figure 3.5: Positive Relationship between 'Mean year of schooling' and Real GDP per capita for Thailand.



<u>Definition</u> Education is composite of two variables, *mean year of schooling and expected years of schooling*.

Education index =

$$\left(\frac{\text{Mean years of schooling}}{15} + \frac{\text{Expected years of schooling}}{18}\right)\Big/2$$

Life expectancy index = f(Life expectancy at birth)

$$= \frac{\text{Life expectancy at birth (years)} - 20}{85 - 20}$$

GNI index is hypothesized to be a function of per capita Gross National Income ($PPP).

= f(GNI per capita ($PPP))

$$= \frac{\log(\text{GNI per capita}/100)}{\log(75{,}000/100)}$$

HDI index is a geometric means of three indices

$$\text{HDI} = \sqrt[3]{\text{Life expectancy index x Education Index x GNI index}}$$

It is calculated from baseline data of Thailand's health index is 0.84 while education index is as low as 0.64 respectively in 2015. It

2.1 Econometric Model and Estimation Result

The system of equations may be simultaneously estimated using 3SLS or GMM. Here the data are from UNDP (2016)

$$\text{GFCFR}(\text{i},\text{t}) = \alpha_0 + \alpha_1 \text{GFCFR}(\text{i},\text{t}-1) + \alpha_2 \text{GDPR} + \alpha_3 \text{URBAN}_{\text{Ratio(i,t)}} + \alpha_4 \left[\frac{\text{MVAR}(\text{i},\text{t})}{\text{GDPR}(\text{i},\text{t})}\right] + \alpha_5 \text{HDI}(\text{i},\text{t}) + \alpha_6 \text{TIME}(\text{t}) + \xi(\text{i},\text{t}) \quad (1)$$

$$\text{HDI}(\text{i},\text{t}) = \beta_0 + \beta_1 Yrs(\text{i},\text{t}) + \beta_2 Life(\text{i},\text{t}) + \beta_3 GDPRcap(\text{i},\text{t}) + \varepsilon \quad (2)$$

$$\left[\frac{\text{GFCFR}}{\text{Pop}}\right] = \alpha_0 + \alpha_1 \left[\frac{\text{GDPR}}{\text{Pop}}\right] + \alpha_2 \text{URBANratio} + \alpha_3 \left[\frac{\text{MVAR}}{\text{Pop}}\right] + \alpha_4 \text{HDI} + \alpha_6 \text{TIME} + \zeta \quad (3)$$

GFCFR(i,t)	= investment expenditure of both physical infrastructure and including social investment in terms of gross fixed capital formation in country i-th at time t; (t=1990,1995,2000,2010,2011-2015)
GDPR (i,t)	= real GDP of country i-th; (in PPP , US$ 2011 constant price)
URBAN(i,t)	=share of an urban population of country i-th; as indices of 'urbanization'
MVAR(i,t)	=the manufacturing value added of country i-th; indices of industrialization
HDI(i)	=Human Development *Index* of country i-th as policy target instrument, with components in the *formula assumed to be policy*

instruments

Yrs(i) = years of schooling an index of Human capital investment
Life(i) = Life expectancy at birth, an index of Health in Human capital investment
GDPRcap = real GDP per capita to represent the level of welfare or well being
TIME(t) =a time dummy as a proxy of trend-setting
ξ, ζ, ε =error terms as the stochastic process

In the model, we assume that human capital can be represented by the '*Human Development Index*'.[4] The social infrastructure investment is *assumed* to rise with the index over time or *vice versa*, other things being constant[5]. Estimation of the above equation of gross investment (including social investment), we have found that the i-th economy has vastly different in sizes, either population, GDP per capita etc. Thus, we may encounter with econometric difficulties like heteroskedsticity and multi-collinearity etc. We, therefore, would also test any other forms of a specification as well. Drop economy *i-th* and time subscript *t* for simplicity.

Since HDI is constructed from per capita income as one component, we may drop GDPR/Pop to avoid over-identification after trials. It may be treated as an instrumental variable instead. The system of equations may be estimated separately as well. It is assumed that there is no feedback of gross investment and HDI component in our model. They are policy instruments. We assume parametric component of the HDI as follows:

Human capital investment in terms of mean year of schooling and live expectancy years has increased over the forecasting horizon to 2030. The wellbeing of Thais is expected to increase in terms of GNI to 20,000 USD, (2011 PPP) in 2030.

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[4] http://hdr.undp.org/en/data
[5] The gross domestic product or income may be endogenously determined the HDI while ODA or government investment (nominal value) on social infrastructure is exogenous.

Table 3.1: Hypothetical Improvement of HD's Component Target 2016-2030

	HDI component			
	expected year schooling(years)	**mean year schooling (years)**	**GNI (2011PPP$)**	**Life expectancy (years)**
2010	13.30	7.30	12,976	73.70
2011	13.70	7.50	13,354	73.90
2012	13.60	7.70	13,993	74.10
2013	13.60	7.90	14,095	74.30
2014	13.60	7.90	14,169	74.40
2015	13.60	7.90	14,519	74.60
2016	13.66	8.03	14,851	74.78
2017	13.65	8.14	15,171	74.97
2018	13.67	8.23	15,419	75.14
2019	13.68	8.29	15,699	75.32
2020	13.83	8.50	16,048	75.73
2021	13.98	8.72	16,405	76.15
2022	14.14	8.93	16,771	76.57
2023	14.30	9.16	17,144	76.99
2024	14.46	9.39	17,525	77.41
2025	14.62	9.62	17,915	77.84
2026	14.78	9.86	18,314	78.27
2027	14.95	10.11	18,722	78.70
2028	15.11	10.36	19,139	79.13
2029	15.28	10.62	19,565	79.56
2030	15.45	10.89	20,000	80.00

The parametric calculation of HDI is by inserting the component into the formula. The assumed level of HDI (sim) is clearly above the business as usual level of HDI(bau)

Table 3.2: Hypothetical HDI, Thailand

	2010	2011	2012	2013	2014
HDI INDEX	0.72	0.73	0.73	0.74	0.74
HDI INDEX (Scenario 1)	0.72	0.73	0.73	0.74	0.74
	2015	2016	2017	2018	2019
HDI INDEX	0.74	0.74	0.75	0.75	0.75
HDI INDEX (Scenario 1)	0.74	0.74	0.75	0.75	0.75
	2020	2021	2022	2023	2024
HDI INDEX	0.76	0.76	0.76	0.77	0.77
HDI INDEX (Scenario 1)	0.76	0.77	0.77	0.78	0.79
	2025	2026	2027	2028	2029
HDI INDEX	0.77	0.77	0.78	0.78	0.78
HDI INDEX (Scenario 1)	0.80	0.80	0.81	0.82	0.83
	2030				
HDI INDEX	0.79				
HDI INDEX (Scenario 1)	0.84				

Figure 3.4: Hypothetical Improvement of HDI in Thailand

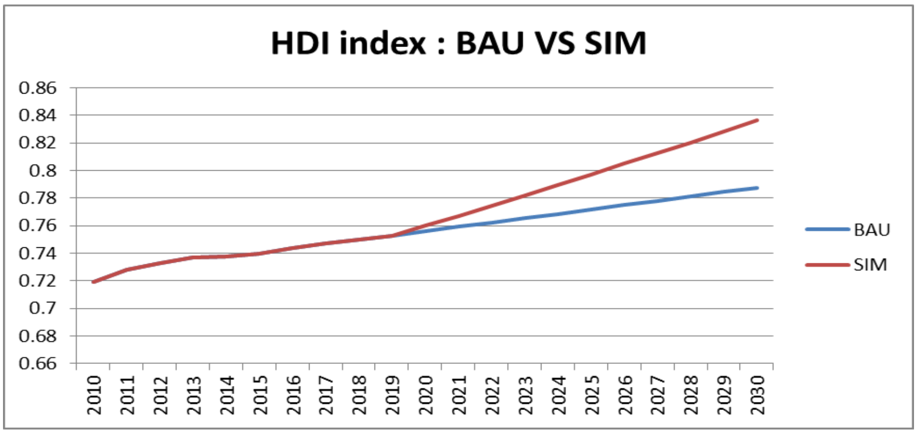


Table 3.3: Hypothetical GDP per capita Thailand as Proxy of Economic Development Level

	2010	2011	2012	2013	2014
GDP per capita (2011 PPP $billions)	13,584.0	13,654.0	14,585.0	14,915.0	14,976.0
GDP per capita (2011 PPP $billions) (scenario 1)	13,584.0	13,654.0	14,585.0	14,915.0	14,976.0
	2015	2016	2017	2018	2019
GDP per capita (2011 PPP $billions)	15,345.0	14,851.0	15,171.0	15,419.0	15,699.0
GDP per capita (2011 PPP $billions) (scenario 1)	15,345.0	14,851.0	15,171.0	15,419.0	15,699.0
	2020	2021	2022	2023	2024
GDP per capita (2011 PPP $billions)	16,024.0	16,343.0	16,660.0	16,974.0	17,304.0
GDP per capita (2011 PPP $billions) (scenario 1)	16,048.0	16,405.0	16,771.0	17,144.0	17,525.0
	2025	2026	2027	2028	2029
GDP per capita (2011 PPP $billions)	17,644.0	17,987.0	18,335.0	18,690.0	19,053.0
GDP per capita (2011 PPP $billions) (scenario 1)	17,915.0	18,314.0	18,722.0	19,139.0	19,565.0
	2030				
GDP per capita (2011 PPP $billions)	19,424.0				
GDP per capita (2011 PPP $billions) (scenario 1)	20,000.0				

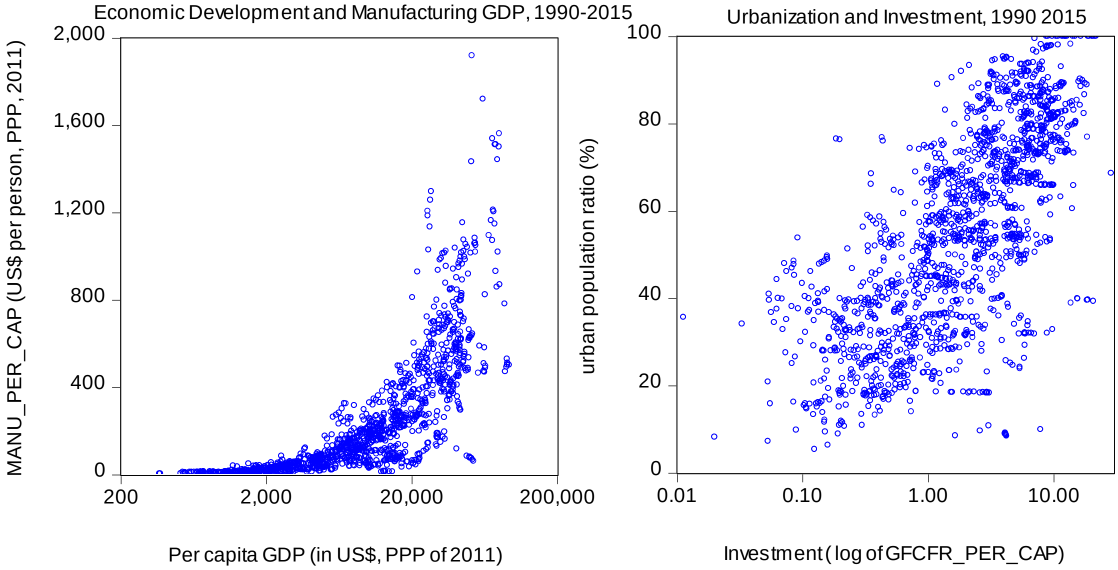
After, we obtain the coefficients from multi-countries experiences; we use this information in the model forecasting. The policy maker is assumed to set a *target* level of *Human capital development* i.e., *schooling achievement years, life expectancy, and well being in terms of per capita income level overtime 2015-2030.*

The NESDB's national account statistic on *Value of Total Construction classified by type of assets* 1993-2016 together with data series of the *private and public construction investment, the capital stock at current replacement cos*t (million baht), the a*nnual depreciation at current replacement cost* are used in our estimation. We calibrate the construction investment with the total gross fixed investment needed for scenarios of the planned level of the HDI mentioned in the equation above over planning horizon 2016-2030. Given the share of construction types in the series, we solve for the investment in construction of buildings and related facilities by *type of social infrastructure*. The postulation of the relationship between total gross investment from model GFCFR is allocated to be and social investment by type j-th respectively.

$$GFCFR\_social(j) = \delta(j)GFCFR \quad (4)$$

$\delta(j)$ =distribution of social infrastructure demand by type j-th, in terms of construction investment by types of assets. Here, *schooling achievement years (j=1), life expectancy (j=2), and well being in terms of per capita income(j=3) level overtime respectively.*

Figure 3.6: Pattern of Growth of Manufacture and Urbanization



Note: Applying multicounty data from UNDP (2016)

Firstly, we have estimated the determination of the **GFCF per capita as a function of HDI** (constant 2011price, $billion). We estimate the Panel Data Model equation (3) mentioned above, applying data from UNDP (2016).

Eq1: gfcfr_per_cap = F(gdpr_per_cap, hdi, year)

LOG(GFCFR_PER_CAP) = 22.9220556556 + 0.037666 + 0.98583802142 * LOG(GDPR_PER_CAP) + 2.39327973596 * LOG(HDI) - 0.0150574835249 * YEAR + [AR(1) = 0.258397813744]

(See Appendix for statistic results)

Eq2: gfcfr = F(gfcfr_per_cap, pop)

GFCFR = GFCFR_PER_CAP * POP

Since the GFCF is nominated in Local Currency Unit (constant 2011 price, billion baht), we, therefore, have to match the GFCF from UNDP database to national account of Thailand in terms of construction investment.

Eq3: gfcfr_lcu = F(gfcfr, p_lcu)

gfcfr_lcu = p_lcu * GFCFR

In addition, we estimate the GDP deflator in local currency unit to be consistent with the data of UNDP.

Eq4: p_lcu = F(gp_lcu, p_lcu)

p_lcu = p_lcu(-1) - 1 * gp_lcu

Now, we have to transform the gross fixed capital formation (GFCF from the model) into the GFCF only for construction investment by public and private sector. The series is from National Account Statistic, these are the construction of

1) Building is residential, industrial, commercial, service & transport building of which social infrastructure investment are school, hospital building
2) other buildings are commercial, industrial, service & transport, dam, road and bridge, and temple respectively
3) other non-building are port, parking lots, advertisement structure, swimming pool, sport structure

The projection of GFCF from the model is translated into the investment in construction by types of asset in current price (in billion baht), assuming the *share* of '*Social Investment*' in terms of building in schooling, health and residents or dwelling inclusive of the housing. The non-construction investment is identified from total GFCF projection after construction investment is projected. In our study, we would like to assume that part of 'public investment' of non-construction can be reallocated to the social infrastructure investment in the mode of types of equipment and laboratory for schools and hospitals. The rest of public investment can be a 'subsidy' for a low-income housing project for the rental resident by NHA (National Housing Authority) in various forms e.g., public-private partnership, or government housing project for the low-rank civil servants, etc.

Eq5: gfcf_lcu = F(gfcfr_lcu, p_gfcf)

gfcf_lcu = p_gfcf * gfcfr_lcu
gfcf_construction = f(gfcf_lcu, con)
gfcf_non_construction = gfcf_lcu – gfcf_construction

Here the gfcf_lcu is a value of total gfcf in a current price of a local currency. The Construction classified by type of assets (in the current price, billion baht), from national account statistic, Thailand. It can be allocated into:

School building

Eq6: gfcf_school_lcu = F(a_school, gfcf_lcu)

gfcf_school_lcu = a_school * gfcf_construction

Health building

Eq7: gfcf_health_lcu = F(a_health, gfcf_construction)

gfcf_health_lcu = a_health * gfcf_construction

Residential building

Eq8: gfcf_resident_lcu = F(a_resident, gfcf_lcu)

gfcf_resident_lcu = a_resident * gfcf_construction

Other building

Eq9: gfcf_otherbuild_lcu = F(a_otherbuild, gfcf_lcu)

gfcf_otherbuild_lcu = a_otherbuild * gfcf_construction

a_health; a_school; a_resident	Share of building investment in construction by type
a_otherbuild	Share of other building 's investment in construction
gdpr_per_cap	GDP per capita (2011 PPP $billions),
gfcf_lcu	Gross fixed capital formation in construction from National account statistic, NESDB (billions baht)
gfcf_health_lcu	Healthcare's social investment (billions baht)
gfcf_otherbuild_lcu	Other building 's social investment
gfcf_resident_lcu	Residential bldg. as social investment (billions baht)
gfcf_school_lcu; gfcf_resident_lcu; gfcf_health_lcu	GFCF constructin by type as social investment by type (billions baht)
gfcfr	Gross fixed capital formation (2011 PPP $ billions), UNDP (2016) from model projection
gfcfr_lcu	Gross fixed capital formation in local currency (constant 2011,billions baht)
gfcf_lcu	Gross fixed capital formation in local currency (current billions baht)
gfcf_construction; gfcf_non_construction	Gross fixed capital formation in local currency (current billions baht) for construction and non-construction
gfcfr_per_cap	Gross fixed capital formation per capita (2011 PPP $ billions), UNDP (2016)
gp_lcu	percent Growth of GFCF price deflator
hdi	HDI index, UNDP (2016)
p_gfcf	Price converter between current and constant price
p_lcu	Price converter between local currency unit and ppp $)
pop	population
year	year

3. Projection of Social Infrastructure Need in terms of Gross Investment

We do simulate the effect of improvement in HDI index altogether with the improvement in GDP per capita.

Figure 3.7: Projection of GFCF with Hypotheical HDI 2016-2030

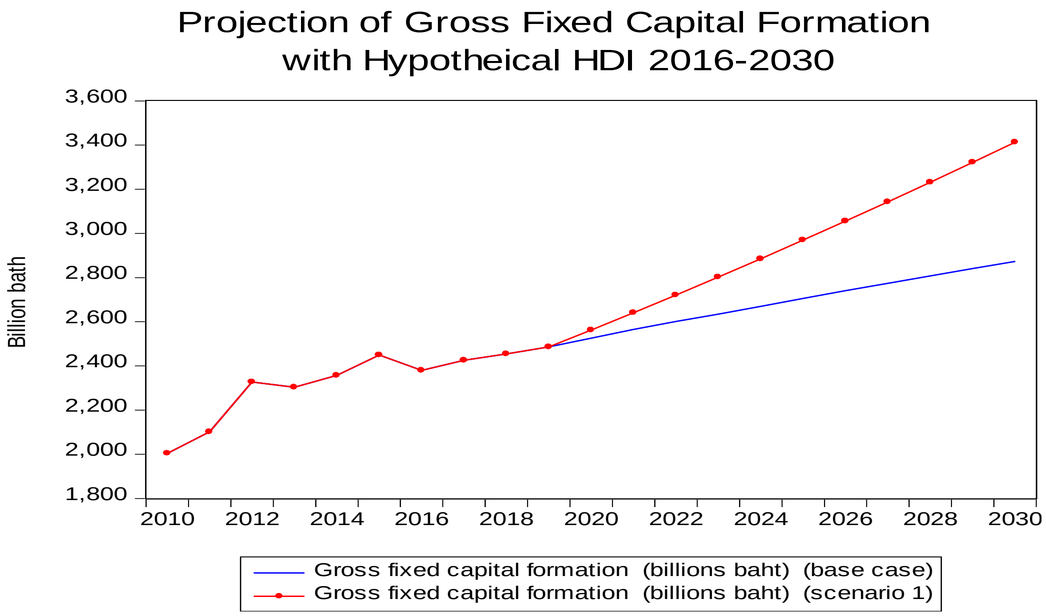


Table 3.4: Gross Fixed Capital Formation (billion baht)

Gross Fixed Capital Formation (Billion baht)	2010	2011	2012	2013	2014
Gross fixed capital formation (billions baht) (base case)	2,004.0	2,101.6	2,327.0	2,303.4	2,356.8
Gross fixed capital formation (billions baht) (scenario 1)	2,004.0	2,101.6	2,327.0	2,303.4	2,356.8
GFCF change from base case (Billion baht)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	2015	2016	2017	2018	2019
Gross fixed capital formation (billions baht) (base case)	2,449.7	2,379.9	2,425.4	2,454.6	2,485.8
Gross fixed capital formation (billions baht) (scenario 1)	2,449.7	2,379.9	2,425.4	2,454.6	2,485.8
GFCF change from base case (Billion baht)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	2020	2021	2022	2023	2024
Gross fixed capital formation (billions baht) (base case)	2,525.6	2,564.8	2,600.8	2,634.7	2,669.9
Gross fixed capital formation (billions baht) (scenario 1)	2,562.2	2,640.6	2,720.8	2,802.2	2,885.2
GFCF change from base case (Billion baht)	**36.6**	**75.8**	**119.9**	**167.5**	**215.3**
	2025	2026	2027	2028	2029
Gross fixed capital formation (billions baht) (base case)	2,705.7	2,740.6	2,774.5	2,807.8	2,840.8
Gross fixed capital formation (billions baht) (scenario 1)	2,969.7	3,055.8	3,143.2	3,232.0	3,322.2
GFCF change from base case (Billion baht)	**264.0**	**315.1**	**368.7**	**424.2**	**481.3**
	2030				
Gross fixed capital formation (billions of baht) (base case)	2,873.4				
Gross fixed capital formation (billions baht) (scenario 1)	3,413.5				
GFCF change from base case (Billion baht)	**540.1**				

Table 3.5: Gross Fixed Capital Formation in Construction and Non-Construction, measured in current prices 2010-2019 (Billion Baht)

item	Description	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	**Gross fixed capital formation (billions of baht) (base case)**	**2003.971**	**2101.552**	**2326.978**	**2303.441**	**2356.783**	**2449.726**	**2379.856**	**2425.434**	**2454.649**	**2485.781**
2	**Gross fixed capital formation (billions of baht) (scenario 1)**	**2003.971**	**2101.552**	**2326.978**	**2303.441**	**2356.783**	**2449.726**	**2379.856**	**2425.434**	**2454.649**	**2485.781**
2.1	Gross fixed capital formation: Construction %	44.75%	43.61%	44.54%	45.68%	44.06%	47.31%	51.45%	51.45%	51.45%	51.45%
2.2	Gross fixed capital formation: Non-construction %	55.25%	56.39%	55.46%	54.32%	55.94%	52.69%	48.55%	48.55%	48.55%	48.55%
3	**Gross fixed capital formation: Construction**										
3.1	RESIDENTIAL%	29.87%	32.21%	31.27%	31.29%	31.65%	27.14%	25.32%	25.32%	25.32%	25.32%
3.2	SCHOOL %	1.97%	1.91%	1.95%	1.87%	1.56%	3.16%[6]	2.75%	2.75%	2.75%	2.75%
3.3	HOSPITAL%	0.75%	0.41%	0.97%	1.18%	1.04%	1.29%	1.52%	1.52%	1.52%	1.52%
3.4	OTHER building%	1.85%	2.47%	3.21%	3.15%	3.49%	3.95%	2.43%	2.43%	2.43%	2.43%
3.5	Other Non-Building %	65.56%	63.00%	62.59%	62.51%	62.26%	64.46%	67.98%	67.98%	67.98%	67.98%
4	**Gross fixed capital formation : Construction (base case)**	**896.772**	**916.455**	**1036.34**	**1052.166**	**1038.466**	**1158.916**	**1224.328**	**1,247.78**	**1,262.81**	**1,278.82**

[6] It is noticed that share in 'school' category of construction as part of the gross fixed capital formation has increased from 1.56 % in 2015 to 3.16 % in 2015 and later decreased to 2.75 % in 2016 to its long-term trend. It is reported in the National Accounts Statistics, NESDB. Our model has applied a normal trend from 2016 for our analysis.

item	Description	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
4.1	Social Infrastructure RESIDENTIAL (base case)	267.8	295.2	324.1	329.3	328.7	314.5	310.0	316.0	319.8	323.8
4.2	Social Infrastructure SCHOOL (base case)	17.7	17.5	20.2	19.7	16.2	36.6	33.7	34.4	34.8	35.2
4.3	Social Infrastructure HOSPITAL (base case)	6.7	3.8	10.1	12.4	10.8	14.9	18.6	19.0	19.2	19.5
4.4	OTHER building (base case)	16.6	22.6	33.3	33.1	36.2	45.8	29.7	30.3	30.6	31.0
4.5	Other Non_Buildings (base case)	587.9	577.4	648.7	657.7	646.5	747.0	832.3	848.2	858.4	869.3
5	**Gross fixed capital formation** : **Construction (scenario1)**	**896.772**	**916.455**	**1036.34**	**1052.166**	**1038.466**	**1158.916**	**1224.328**	**1,247.78**	**1,262.81**	**1,278.82**
5.1	Social Infrastructure RESIDENTIAL (scenario 1)	267.8	295.2	324.1	329.3	328.7	314.5	310.0	316.0	319.8	323.8
5.2	Social Infrastructure SCHOOL (scenario 1)	17.7	17.5	20.2	19.7	16.2	36.6	33.7	34.4	34.8	35.2
5.3	Social Infrastructure HOSPITAL (scenario 1)	6.7	3.8	10.1	12.4	10.8	14.9	18.6	19.0	19.2	19.5
5.4	OTHER building (scenario 1)	16.6	22.6	33.3	33.1	36.2	45.8	29.7	30.3	30.6	31.0
5.5	Other Non-Building (scenario 1)										

item	Description	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
		587.9	577.4	648.7	657.7	646.5	747.0	832.3	848.2	858.4	869.3
6	**Gross fixed capital formation: Non-construction**										
6.1	Private %	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
6.2	Public %	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
6.2.1	Education %	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
6.2.2	Health %	48%	48%	48%	48%	48%	48%	48%	48%	48%	48%
6.2.3	Residential%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
7	**Social Infrastructure Investment Need ,**	**1,107.20**	**1,185.10**	**1,290.64**	**1,251.28**	**1,318.32**	**1,290.81**	**1,155.53**	**1,177.66**	**1,191.84**	**1,206.96**
	Non-construction (base case)										
7.1	**Public**	**221.44**	**237.02**	**258.13**	**250.26**	**263.66**	**258.16**	**231.11**	**235.53**	**238.37**	**241.39**
7.1.1	Education	88.58	94.81	103.25	100.10	105.47	103.26	92.44	94.21	95.35	96.56
7.1.2	Health	106.29	113.77	123.90	120.12	126.56	123.92	110.93	113.06	114.42	115.87
7.1.3	Residential	4.43	4.74	5.16	5.01	5.27	5.16	4.62	4.71	4.77	4.83

Source: Model simulation in this study; see system model and applying national accounts of Thailand

Table 3.6: Social Infrastructure Investment Need 2020-2030, measured in current price (Billion Baht)

Item	Description	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	**Gross fixed capital formation (billions of baht) (base case)**	**2525.593**	**2564.822**	**2600.817**	**2634.717**	**2669.888**	**2705.744**	**2740.647**	**2774.497**	**2807.834**	**2840.823**	**2873.385**
2	**Gross fixed capital formation (billions of baht) (scenario 1)**	**2562.221**	**2640.628**	**2720.754**	**2802.241**	**2885.197**	**2969.723**	**3055.753**	**3143.219**	**3232.045**	**3322.151**	**3413.456**
2.1	Gross fixed capital formation: Construction %	51.45%	51.45%	51.45%	51.45%	51.45%	51.45%	51.45%	51.45%	51.45%	51.45%	51.45%
2.2	Gross fixed capital formation: Non-construction %	48.55%	48.55%	48.55%	48.55%	48.55%	48.55%	48.55%	48.55%	48.55%	48.55%	48.55%
3	**Gross fixed capital formation: Construction**											
3.1	RESIDENTIAL%	25.32%	25.32%	25.32%	25.32%	25.32%	25.32%	25.32%	25.32%	25.32%	25.32%	25.32%
3.2	SCHOOL %	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%
3.3	HOSPITAL%	1.52%	1.52%	1.52%	1.52%	1.52%	1.52%	1.52%	1.52%	1.52%	1.52%	1.52%
3.4	OTHER building %	2.43%	2.43%	2.43%	2.43%	2.43%	2.43%	2.43%	2.43%	2.43%	2.43%	2.43%
3.5	Other Non-Building %	67.98%	67.98%	67.98%	67.98%	67.98%	67.98%	67.98%	67.98%	67.98%	67.98%	67.98%
4	**Gross fixed capital**	**1,299.30**	**1,319.48**	**1,338.00**	**1,355.44**	**1,373.54**	**1,391.98**	**1,409.94**	**1,427.35**	**1,444.50**	**1,461.47**	**1,478.23**

Item	Description	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	formation: Construction (base case)											
4.1	Social Infrastructure RESIDENTIAL (base case)	329.0	334.1	338.8	343.2	347.8	352.5	357.0	361.4	365.8	370.1	374.3
4.2	Social Infrastructure SCHOOL (base case)	35.8	36.3	36.8	37.3	37.8	38.3	38.8	39.3	39.8	40.2	40.7
4.3	Social Infrastructure HOSPITAL (base case)	19.8	20.1	20.4	20.6	20.9	21.2	21.5	21.7	22.0	22.2	22.5
4.4	OTHER building (base case)	31.5	32.0	32.5	32.9	33.3	33.8	34.2	34.6	35.0	35.4	35.9
4.5	Other Non_Buildings (base case)	883.2	896.9	909.5	921.4	933.7	946.2	958.4	970.3	981.9	993.5	1,004.9
5	**Gross fixed capital formation : Construction (scenario1)**	**1,318.15**	**1,358.48**	**1,399.70**	**1,441.63**	**1,484.30**	**1,527.79**	**1,572.05**	**1,617.04**	**1,662.74**	**1,709.10**	**1,756.07**
5.1	Social Infrastructure RESIDENTIAL (scenario 1)	333.8	344.0	354.4	365.1	375.9	386.9	398.1	409.5	421.0	432.8	444.7
5.2	Social Infrastructure SCHOOL (scenario 1)	36.3	37.4	38.5	39.7	40.9	42.1	43.3	44.5	45.8	47.1	48.4
5.3	Social Infrastructure HOSPITAL (scenario 1)	20.1	20.7	21.3	21.9	22.6	23.3	23.9	24.6	25.3	26.0	26.7

Item	Description	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
5.4	OTHER building (scenario 1)	32.0	32.9	33.9	35.0	36.0	37.1	38.1	39.2	40.3	41.5	42.6
5.5	Other Non-Building (scenario 1)	896.0	923.5	951.5	980.0	1,009.0	1,038.5	1,068.6	1,099.2	1,130.3	1,161.8	1,193.7
6	**Change in Gross fixed capital formation: Construction**	18.84	39.00	61.70	86.18	110.77	135.81	162.11	189.69	218.24	247.62	277.84
6.1	Social Infrastructure RESIDENTIAL (Change)	4.77	9.88	15.62	21.82	28.05	34.39	41.05	48.03	55.26	62.70	70.36
6.2	Social Infrastructure SCHOOL (Change)	0.52	1.07	1.70	2.37	3.05	3.74	4.46	5.22	6.01	6.82	7.65
6.3	Social Infrastructure HOSPITAL (Change)	0.29	0.59	0.94	1.31	1.69	2.07	2.47	2.89	3.32	3.77	4.23
6.4	OTHER building (Change)	0.46	0.95	1.50	2.09	2.69	3.29	3.93	4.60	5.29	6.01	6.74
6.5	Other Non-Building (Change)	12.81	26.51	41.94	58.58	75.30	92.32	110.20	128.95	148.35	168.33	188.87
7	**Gross fixed capital formation: Non-construction**											
7.1	Private %	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
7.2	Public %	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
7.2.1	Education %	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%

Item	Description	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
7.2.2	Health %	48%	48%	48%	48%	48%	48%	48%	48%	48%	48%	48%
7.2.3	Residential%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
8	**Social Infrastructure Investment Need ,**	**1,226.29**	**1,245.34**	**1,262.81**	**1,279.27**	**1,296.35**	**1,313.76**	**1,330.71**	**1,347.14**	**1,363.33**	**1,379.35**	**1,395.16**
	Non construction (base case)											
8.1	**Public**	**245.26**	**249.07**	**252.56**	**255.85**	**259.27**	**262.75**	**266.14**	**269.43**	**272.67**	**275.87**	**279.03**
8.1.1	Education	98.10	99.63	101.03	102.34	103.71	105.10	106.46	107.77	109.07	110.35	111.61
8.1.2	Health	117.72	119.55	121.23	122.81	124.45	126.12	127.75	129.33	130.88	132.42	133.94
8.1.3	Residential	4.91	4.98	5.05	5.12	5.19	5.26	5.32	5.39	5.45	5.52	5.58
9	**Social Infrastructure Investment Need,**	**1,244.07**	**1,282.14**	**1,321.05**	**1,360.62**	**1,400.89**	**1,441.94**	**1,483.71**	**1,526.18**	**1,569.30**	**1,613.05**	**1,657.39**
	Non-construction (scenario 1)											
9.1	**Public**	**248.81**	**256.43**	**264.21**	**272.12**	**280.18**	**288.39**	**296.74**	**305.24**	**313.86**	**322.61**	**331.48**
9.1.1	Education	99.53	102.57	105.68	108.85	112.07	115.35	118.70	122.09	125.54	129.04	132.59
9.1.2	Health	119.43	123.09	126.82	130.62	134.49	138.43	142.44	146.51	150.65	154.85	159.11
9.1.3	Residential	4.98	5.13	5.28	5.44	5.60	5.77	5.93	6.10	6.28	6.45	6.63
10	**Social Infrastructure Investment Need,**	**17.78**	**36.81**	**58.23**	**81.34**	**104.54**	**128.17**	**153.00**	**179.03**	**205.97**	**233.71**	**262.23**
	Non-construction, Additional											

Item	Description	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
10.1	**Public**	**3.56**	**7.36**	**11.65**	**16.27**	**20.91**	**25.63**	**30.60**	**35.81**	**41.19**	**46.74**	**52.45**
10.1.1	Education	1.42	2.94	4.66	6.51	8.36	10.25	12.24	14.32	16.48	18.70	20.98
10.1.2	Health	1.71	3.53	5.59	7.81	10.04	12.30	14.69	17.19	19.77	22.44	25.17
10.1.3	Residential	0.07	0.15	0.23	0.33	0.42	0.51	0.61	0.72	0.82	0.93	1.05

Source: Model simulation in this study; see system model and applying national accounts of Thailand

It should be noted that the demand for social infrastructure projected from a hypothetical target of HDI component would be oriented to the physical assets i.e., building proper. The investment in learning facilities, laboratory equipment, computers and software in the education system as well as hospital types of equipment with high technology and costly would be considered to be re-allocated from 'public investment' in the non-construction. However, the social investment in hospital facilities can be done explicitly in the projection. The availability of data has limited such possibility.

4. *Hypothetical* Macroeconomic Impact of the Investment in Social Infrastructure

In order to evaluate the impact of hypothetical investment in human capital education and health as well as the wellbeing of the population via low-income housing, have applied an economic model to assess the impact.

Model simulation is based on 'A Computable General Equilibrium Model' by N. Puttanapong, K.Limskul and T.Bowonthumrongchai (2017)[7]'s model. In brief, the model consists of 5 parts, 3 Players: 9 Production sectors, domestic agents (Household and Government) and Foreign agent (Rest of the world) and 2 markets: good and services markets and primary factor markets and 4 type of labors, Thai nationals and foreign migrants 'Skilled-unskilled labor' respectively. We also have 7 households with 5 income classes. The model has applied database from Social Account Matrix (SAM) based on the official Input-Output table of 2010 published by NESDB with a brief description as follows:

The household is disaggregated into the household by income type, labor by skilled and nationality according to data combination from the Social-economic survey 2009, Labor force survey 2010 and national household census 2010 respectively.

The model is a system of equations representing equilibrium in the product market, labor market through price and quantity adjustment. For sake of simplicity, we do not show the whole system of equations. At macro-economic equilibrium, the aggregate demand and supply are simultaneously reached.

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[7] N. Puttanapong, K.Limskul and T.Bowonthumrongchai (2017), A Study on Macroeconomic Impacts of Immigration Using a SAM-Based CGE model, summited to OECD (2017), *How Immigrant Contributed to Thailand's Economy.*
https://www.oecd.org/migration/how-immigrants-contribute-to-Thailand-s-economy-9789264287747-en.htm

We are interested in the role of human capital investment as well as wellbeing improvement through residential investment. The incremental human capital investment will have an impact on return on investment through rising productivity and wage. Following Meijl et al. (2006)[8] and Berrittella (2012)[9], defines the labor supply curve which is the function of wage. This model applied the projection of labor force Thailand[10] and main countries of origin of immigrants[11] as the value of *LMAX*. (Details of these projections are shown in Appendix A).

$$LS_{l,t} = LMAX_{l,t} - \frac{\beta_{l,t}}{{Wage_{l,t}}^{\alpha_{l,t}}}$$

where

$LS_{l,t}$	: Supply of type *l* labor
$LMAX_{l,t}$	: Maximum of working force of type *l* labor
$Wage_{l,t}$	: Average wage of type *l* labor
$\beta_{l,t}$	: Constant of labor supply equation (for type *l* labor)
$\alpha_{l,t}$	: Elasticity of labor supply equation (for type *l* labor)

The dynamic growth path of the economy is governed by the inter-temporal accumulation of capital. It obeys the dynamic relationship between investment, capital stock, and depreciation.

$$KD_{k,j,t+1} = KD_{k,j,t}(1 - \delta_{k,j}) + IND_{k,j,t}$$

where

$IND_{k,j,t}$: Type *k* of new capital investment in sector *j* (whether public or private)

$\delta_{k,j}$: Depreciation rate of capital of type *k* used in industry *j*

$$IT_t^{PUB} = PK_t^{PUB} \sum_{k,pub} IND_{k,pub,t}$$

where

PK_t^{PUB}	: Price of new public capital
$IND_{kpub,t}$	: Type *k of* new capital investment volume in public sector

8 Van Meijl, H., T. van Rheenen, A. Tabeau and B. Eickhout (2006), "The impact of different policy environments on agricultural land use in Europe", Agriculture, Ecosystems & Environment, Vol. 114, No. 1.

9 Berrittella, M. (2012), "Modelling the labor market of minority ethnic groups", Journal of Policy Modeling, Vol. 34, No. 3.

10 The official projection of Thai population has been jointly conducted by National Economic and Social Development Board and Institute of Population and Social Research of Mahidol University

11 The projection of population and labor force of Myanmar, Lao PDR and Cambodia is undertaken by The Frederick S. Pardee Center for International Futures, University of Denver

$IT_t^{PRI} = PK_t^{PRI} \sum_{k,bus} IND_{k,bus,t}$

where

PK_t^{PRI} : Price of new private capital

$IND_{k,bus,t}$: Type k of new capital investment volume in private business sector

In our context, the investment of public and private construction by asset type mention earlier would provide a basis for the dynamic economic growth of Thai economy.

In model simulation, the growth of HDI's component is estimated to raise the Total Factor Productivity or a shift parameter in the production function in the model. In addition, the labor productivity is assumed to grow as HDI component like mean years of schooling, expected a year of schooling, life expectancy is assumed to grow in line with the assumption in the last section. The shift parameters, as well as labor input, will drive the increase of production. It is assumed also that the investment in buildings or social investment in our study will raise the capital stock growth. Given the growth path assumed in the business as usual of future scenarios, the growth potential by HDI target elements will drive additional growth on both supply and demand side as shown in macroeconomic impact below.

The HDI target will give rise to a solution to replace the unskilled labor from neighboring countries in the long-run. The physical capital investment in couple with human capital investment will hypothetically raise the labor productivity towards sustained growth in the long-run 2020-2030. We have applied the CGE model mentioned above but show only the macroeconomic impact here. The overall real GDP's gain as a result of HDI component as well as gains from the aggregate demand or expenditure side is shown in the table.

Table 3.7: Impact of Hypothetical Investment in Social Infrastructure on Thai Macro Economy 2020-2030

Macro Variables (measured in billion baht)	2020	2021	2022	2023	2024
Change in Real Gross Domestic Product	8.6	17.8	28.7	41.0	54.9
Change in Real Export	3.2	6.8	11.2	16.3	22.2
Change in Real Government Expenditure	1.7	3.3	5.1	7.0	9.0
Change in Gross Fixed Capital Formation	2.4	5.0	8.1	11.8	16.1
Change in Real Import	2.8	6.0	9.8	14.3	19.5
Change in Private Consumption Expenditure	3.8	8.0	12.9	18.6	25.1
	2025	2026	2027	2028	2029
Change in Real Gross Domestic Product	70.4	87.9	107.7	129.9	155.0
Change in Real Export	28.9	36.7	45.8	56.2	68.2
Change in Real Government Expenditure	11.1	13.3	15.6	18.0	20.7
Change in Gross Fixed Capital Formation	20.9	26.5	32.9	40.2	48.6
Change in Real Import	25.5	32.5	40.5	49.8	60.6
Change in Private Consumption Expenditure	32.3	40.5	49.8	60.4	72.3
	2030				
Change in Real Gross Domestic Product	183.1				
Change in Real Export	82.0				
Change in Real Government Expenditure	23.5				
Change in Gross Fixed Capital Formation	58.1				
Change in Real Import	72.9				
Change in Private Consumption Expenditure	85.7				

Note: Direct summation of right –hand real expenditure change is not matched to change in real GDP owing to we did not add the change in investment in the table. Besides, the change has to be weighted by GDP share.

Appendix

Table A3-1: Determination of Real Gross Fixed Capital Formation (GFCFR)

Dependent Variable: GFCFR

Method: Panel EGLS (Period random effects)

Sample (adjusted): 1995 2015

Periods included: 9

Cross-sections included: 157

Total panel (unbalanced) observations: 1187

Swamy and Arora estimator of component variances

Cross-section SUR (PCSE) standard errors & covariance (d.f. corrected)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	24.94328	6.771433	3.683604	0.0002
GFCFR(-1)	1.020276	0.154731	6.593870	0.0000
URBAN_POP	-0.209444	0.083715	-2.501886	0.0125
MANU_SHARE	1.427857	0.605181	2.359389	0.0185
HDI	-51.02846	16.05867	-3.177626	0.0015
GDPR	0.021882	0.035602	0.614635	0.5389

Effects Specification

	S.D.	Rho
Period random	0.000000	0.0000
Idiosyncratic random	92.82143	1.0000

Weighted Statistics

R-squared	0.970836	Mean dependent var	144.0161
Adjusted R-squared	0.970713	S.D. dependent var	543.1343
S.E. of regression	92.94946	Sum squared resid	10203369
F-statistic	7862.875	Durbin-Watson stat	1.150210
Prob(F-statistic)	0.000000		

Unweighted Statistics

R-squared	0.970836	Mean dependent var	144.0161
Sum squared resid	10203369	Durbin-Watson stat	1.150210

Table A3-2: Determination of Real Gross Fixed Capital Formation per capita

Dependent Variable: LOG(GFCFR_PER_CAP)

Method: Generalized Linear Model (Newton-Raphson / Marquardt steps)

Sample: 1990 2015

Included observations: 1286

Dispersion computed using Pearson Chi-Square

Coefficient covariance computed using observed Hessian

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-4.410516	0.108404	-40.68589	0.0000
LOG(MANU_PER_CAP)	0.261630	0.017525	14.92905	0.0000
LOG(URBAN_POP)	0.147137	0.036183	4.066418	0.0000
HDI	4.812901	0.168638	28.53978	0.0000

Mean dependent var	0.708444	S.D. dependent var	1.268308
Sum squared resid	282.7789	Log likelihood	-850.8531
Akaike info criterion	1.329476	Schwarz criterion	1.345524
Hannan-Quinn criter.	1.335500	Deviance	282.7789
Deviance statistic	0.220576	Restr. deviance	2067.059
LR statistic	8089.172	Prob(LR statistic)	0.000000
Pearson SSR	282.7789	Pearson statistic	0.220576
Dispersion	0.220576		

Note: Explanation of the signs of estimated coefficients.

(1) Description of variables: URBAN_POP = urban population; MANU_SHARE = share of manufacturing GDP; HDI = Human Development Index; GDPR= Gross Domestic Product (constant price); GDPR_PER_CAP= real GDP per capita;

(2) The coefficient of determination of Gross Fixed Capital Formation (GFCF) by HDI is -**51.02846** (**level variables**)**, while** the 'log of GFCF per capita' determined by the log of HDI is however is +**2.39328**.

It can be rationalized as follows: First, the level of GFCF is negatively correlated with HDI since the relationship is convex. The marginal increment of HDI by GFCF increases with a decreasing rates. The inverse relationship is negatively shown by the coefficients estimates. The per capita income one of the HDI's component is convex and has a negative relationship with the economic welfare level.

Secondly, after 'log linearization' of the variables GFCFR_Per_Capita and HDI. The positive coefficient measured 'elasticity' of HDI index on the gross fixed capital formation per capita by 2.39 percent.

The HDI is an index representing the 'loci of equality between demand and supply for human capital inputs at 'equilibrium'. Thus, *around the neighborhood of equilibrium* position, the *increase of gross fixed capital formation per capita induced a positive growth of HDI* especially the per capita income or welfare of samples country (given the year of schooling, and the life expectancy) assuming the inverse relationship exists.