CS752: System Dynamics

Project Submission Report

Group Name: Causal Thinkers

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India’s Demographic Edge: A Race Against Time

Problem Statement:

Demographic Opportunity & Risk: India has a large youth population that can drive economic growth if properly harnessed, but neglecting proper investment could lead to a demographic disaster.

Key Challenges:

- Gaps in education quality and skill development.
- Limited employment opportunities.
- Inadequate infrastructure.

Potential Consequences (if no action is taken):

- Rising unemployment and economic stagnation.
- Social instability and increased burden on welfare systems.
- Loss of global competitiveness.

How can India effectively utilize its youth population and prevent it from becoming a liability in the next few decades?

Objective:

- To show if the corruption is not managed properly it can lead to economic collapse of india.
- To show how India’s growing youth population can be transformed into a productive workforce.
- To examine the role of government initiatives in education and infrastructure development.
- To understand the impact of increased skill development on reducing unskilled labour.
- To explore how a skilled workforce can attract more businesses and enhance entrepreneurship.
- To assess how these factors can enhance government funds and long-term economic growth.

Scope:

- The model encompasses four interconnected systems: population demographics, government finance, education infrastructure, and economic development
- Time horizon spans multiple decades to capture full lifecycle effects from education investment to workforce outcomes to retirement
- Geographical scope is India with aggregated population segments rather than individual-level dynamics

- The model focuses on macro-level policy decisions rather than micro-level behavioral changes
- Includes basic representation of economic feedback loops without detailed industry-specific modeling

Assumptions:

Structural Assumptions

- **Age Segmentation:** Population is divided into three fixed age groups (0–22, 23–59, 60+) with clear transitions.
- **Binary Skills:** Workforce is either “skilled” or “unskilled,” with no gradation.
- **Infrastructure Decay:** Education and economic infrastructure degrade similarly if not maintained.
- **Closed System:** No migration or external economic interactions are modeled.

Behavioral Assumptions

- **Rational Government:** Resource allocation is based solely on calculated needs and priorities.
- **Predictable Tax Behavior:** Taxpayers respond consistently to tax changes, without avoidance.
- **Direct Education Impact:** Education quality directly drives skill acquisition.
- **Company Dynamics:** Business formation/closure is driven by infrastructure and workforce, not innovation or markets.

Parameter Assumptions

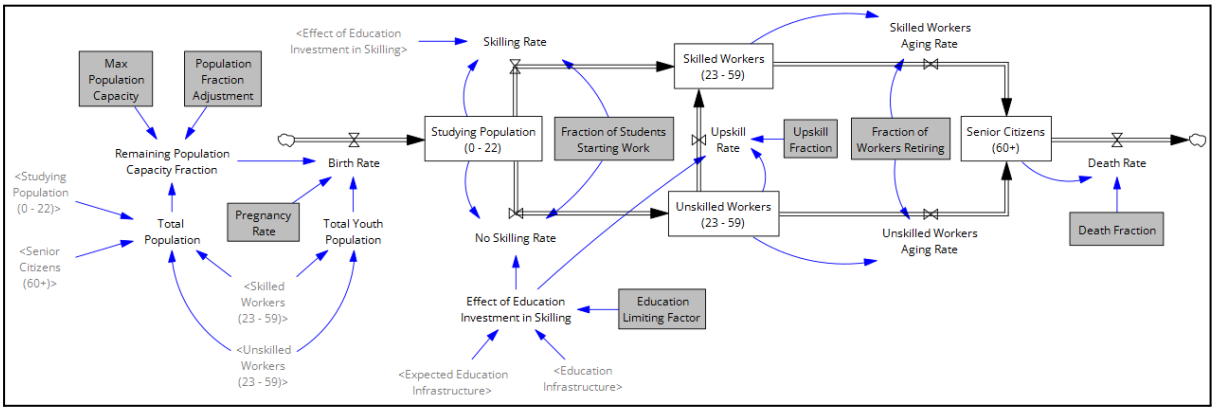
- **Fixed Transitions:** Demographic and workforce transitions are constant over time.
- **Uniform Infrastructure Needs:** All sectors are assumed to need similar infrastructure.
- **Predictable Corruption Impact:** Corruption effects on investment are consistent and linear.
- **Linear Relationships:** Most causal relationships are modeled as linear.

Temporal Assumptions

- **Aligned Time Scales:** All system changes occur over similar time frames.
- **Stable External Context:** External factors like technology and climate are assumed stable.
- **Instant Information:** Decision-makers have immediate, accurate system data.

SFD Model:

Population and Workforce Dynamics



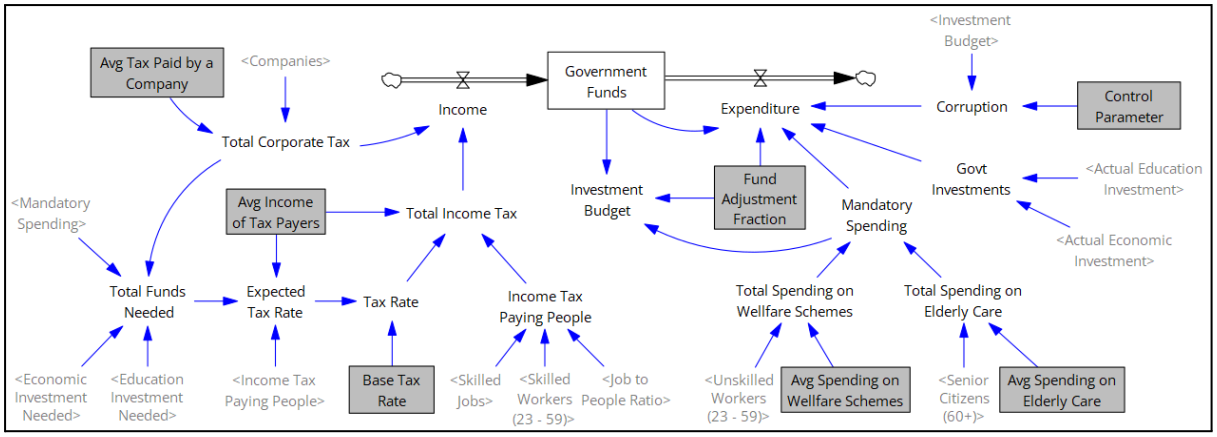
This model illustrates the flow of population through different life stages and skill acquisition pathways. The population is segmented into four main stocks: the studying population (ages 0-22), working-age population (divided into skilled and unskilled workers, ages 23-59), and senior citizens (60+).

Key dynamics captured:

- **Population growth** is influenced by birth rates, which depend on pregnancy rates and total youth population
- **Skill acquisition pathways** show how the studying population transitions into either skilled or unskilled workforce based on skilling rates
- **Education investment effects** are represented by connections between education infrastructure and skilling rates
- **Aging processes** demonstrate how both skilled and unskilled workers eventually transition to senior citizens
- **Population constraints** are modeled through the maximum population capacity and population fraction adjustment

This model effectively captures the demographic transitions and human capital development processes that form the foundation of the labor market. It demonstrates how educational investment influences workforce composition, which subsequently affects economic productivity and social welfare systems.

Government Fiscal Dynamics



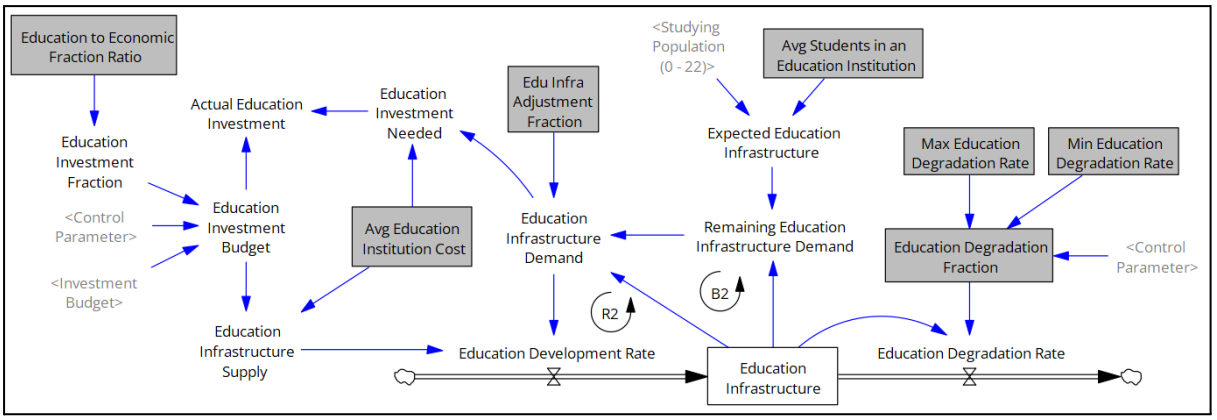
This model represents the flow of government funds and the fiscal policy mechanisms that influence public spending priorities. It shows how tax revenue is generated, allocated, and spent across different sectors.

Key dynamics captured:

- **Revenue generation** through corporate and income taxes based on population segments and economic activity
- **Budget allocation mechanisms** showing how government funds are distributed between investment and mandatory spending
- **Corruption effects** on expenditure efficiency and actual investment realized
- **Welfare spending determinants** based on specific population needs (elderly care, unemployment benefits)
- **Fiscal planning elements** including fund adjustment fractions and expected tax rates
- **Feedback loops** between government investment and economic growth potential

This model illustrates the fiscal constraints and policy levers available to governments, demonstrating how taxation and spending decisions create feedback loops that affect economic development and social welfare outcomes.

Education Infrastructure Dynamics



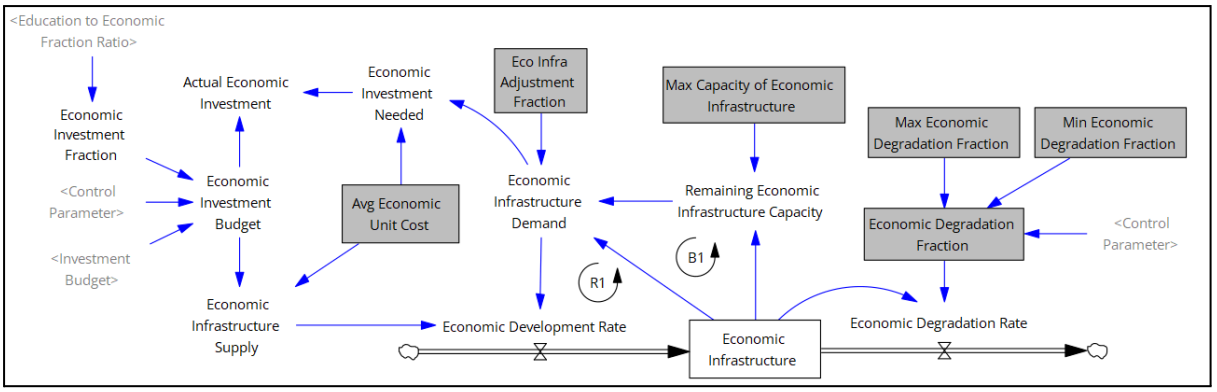
This model focuses on the education system infrastructure, showing how investment in education translates into infrastructure development, maintenance, and quality.

Key dynamics captured:

- **Education investment budget determination** based on government budget allocation and economic priorities
- **Infrastructure supply and demand balancing** through development rates and degradation processes
- **Cost factors** related to educational institutions and infrastructure maintenance
- **Quality control mechanisms** through minimum and maximum degradation rates
- **Carrying capacity concepts** that link student population to infrastructure requirements
- **Feedback loops** (B2 and R2) that demonstrate how infrastructure quality affects educational outcomes

This model demonstrates the critical role of sustained investment in maintaining educational quality, showing how infrastructure degradation can undermine skills development when maintenance is neglected.

Economic Infrastructure Dynamics



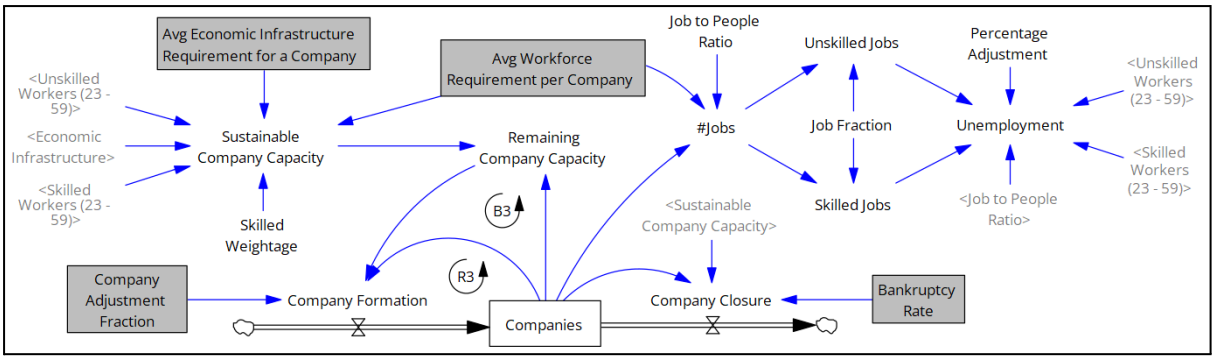
This model parallels the education infrastructure model but focuses on economic infrastructure that supports business activity and job creation.

Key dynamics captured:

- **Economic investment prioritization** showing how government funds are allocated to economic development
- **Infrastructure capacity and demand balancing** mechanisms similar to the education model
- **Development and degradation rates** affecting the quality and quantity of economic infrastructure
- **Cost factors** related to economic infrastructure development and maintenance
- **Feedback loops** (B1 and R1) showing how infrastructure quality influences economic growth potential

This model illustrates how economic infrastructure serves as a foundation for business activity, affecting the economy's capacity to generate jobs and wealth. The balancing and reinforcing loops demonstrate the importance of sustainable investment strategies.

Business and Employment Dynamics



This model represents how companies form, operate, and close, focusing on their relationship with the workforce and economic infrastructure.

Key dynamics captured:

- **Company formation and closure processes** influenced by economic conditions and bankruptcy rates
- **Job creation mechanisms** showing how companies generate both skilled and unskilled employment opportunities
- **Workforce requirements** demonstrating how companies depend on available skilled and unskilled workers
- **Unemployment dynamics** affected by the job-to-people ratio and available workforce
- **Infrastructure dependencies** showing how economic infrastructure supports business activity
- **Feedback loops** (B3 and R3) illustrating the self-reinforcing nature of business development when conditions are favorable

This model effectively captures how companies serve as intermediaries between infrastructure and employment, translating economic capacity into jobs that utilize the available workforce.

Key Feedback Loops:

1: Skills Development Reinforcing Loop

Education investment → Education infrastructure → Skilling rate → Skilled workers → Companies → Tax revenue → Government funds → Education investment

This reinforcing loop shows how investment in education creates skilled workers who support economic growth, generating tax revenue that can be reinvested in education.

2: Economic Development Reinforcing Loop

Economic investment → Economic infrastructure → Company formation → Jobs → Tax revenue → Government funds → Economic investment

This loop demonstrates how economic infrastructure investment leads to business growth, employment, and tax revenue that enables further infrastructure investment.

3: Fiscal Constraint Balancing Loop

Government funds → Multiple spending demands (education, economic, welfare, elderly) → Limited fiscal capacity → Budget constraints → Investment limitations → Infrastructure degradation → Economic challenges → Reduced tax revenue → Lower government funds

This balancing loop captures the fiscal constraints that governments face when allocating limited resources across competing priorities.

4: Infrastructure Capacity Balancing Loop

Population growth → Infrastructure demand → Infrastructure development → Capacity constraints → Development limitations → Service quality decline → Potential demographic impacts → Population adjustments

This loop shows how infrastructure capacity must continually adapt to population changes, with potential constraints affecting service quality.

5: Skilled Labor Premium Reinforcing Loop

Skilled workers → Company formation → Skilled jobs → Employment opportunities → Tax revenue → Education investment → Skilling rate → More skilled workers

This reinforcing loop highlights how skilled workers create demand for more skilled jobs, potentially creating a virtuous cycle of skills development.

6: Unemployment Adjustment Balancing Loop

Job to people ratio → Unemployment → Labor market adjustments → Wage pressures → Company formation/closure dynamics → Jobs → Job to people ratio

This balancing loop demonstrates how labor markets adjust to create equilibrium between available jobs and workforce.

7: Corruption-Investment Degradation Loop

Corruption → Reduced effective investment → Infrastructure degradation → Economic challenges → Fiscal pressure → Potential governance issues → Increased corruption

This reinforcing loop shows how corruption can create a downward spiral of reduced investment effectiveness and economic deterioration.

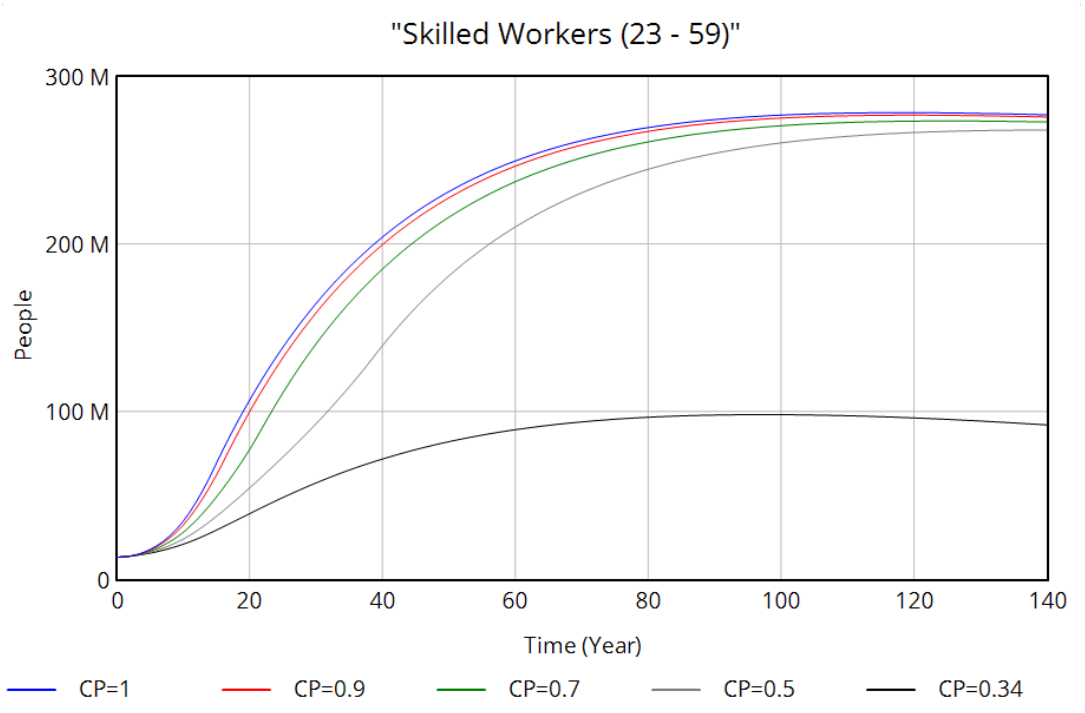
8: Human Capital Development Loop

Education infrastructure → Skilling rate → Skilled workforce → Economic productivity → Tax revenue → Education investment → Education infrastructure

This reinforcing loop focuses specifically on how human capital development feeds back into economic productivity and enables further investment.

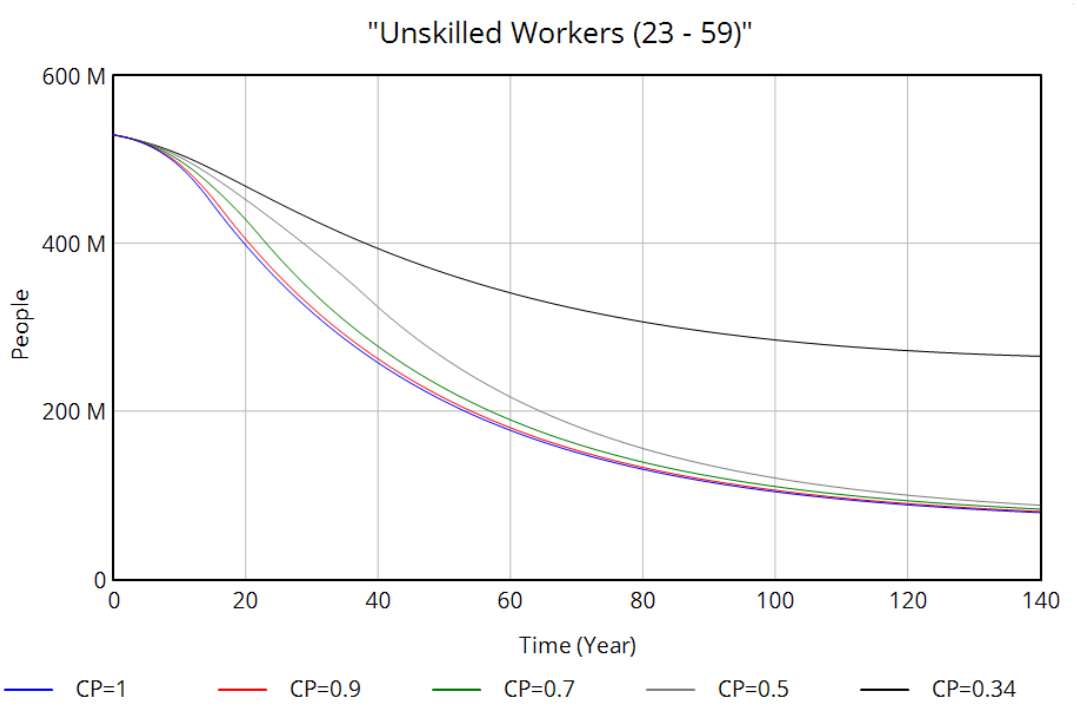
Graphs and Observations:

Skilled Workers Graph



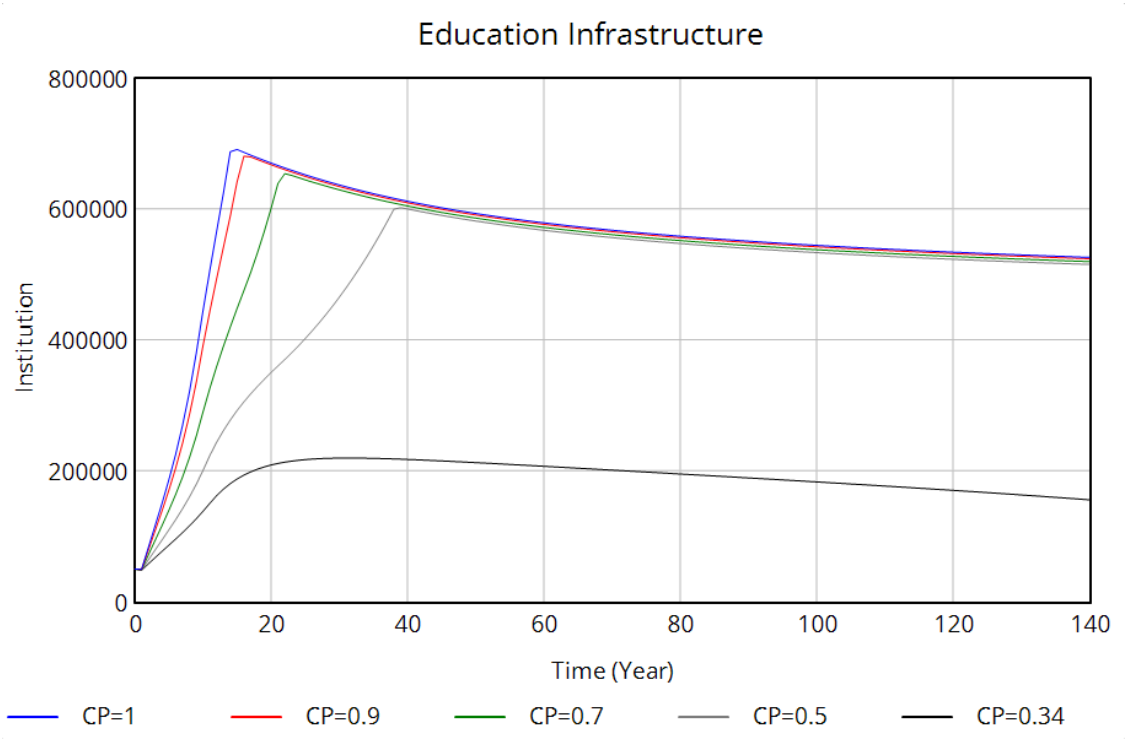
- Low corruption (CP=0.9-1) enables rapid growth in skilled workers, reaching around 280M by year 100.
- Moderate corruption delays but doesn't prevent skilled workforce development, with CP=0.5-0.7 eventually approaching similar levels.
- High corruption (CP=0.34) severely limits skilled workforce development, capping at approximately 100M workers - less than half the potential shown in better scenarios.
- The transition from unskilled to skilled workers is dramatically more efficient in low-corruption environments.

Unskilled Workers Graph



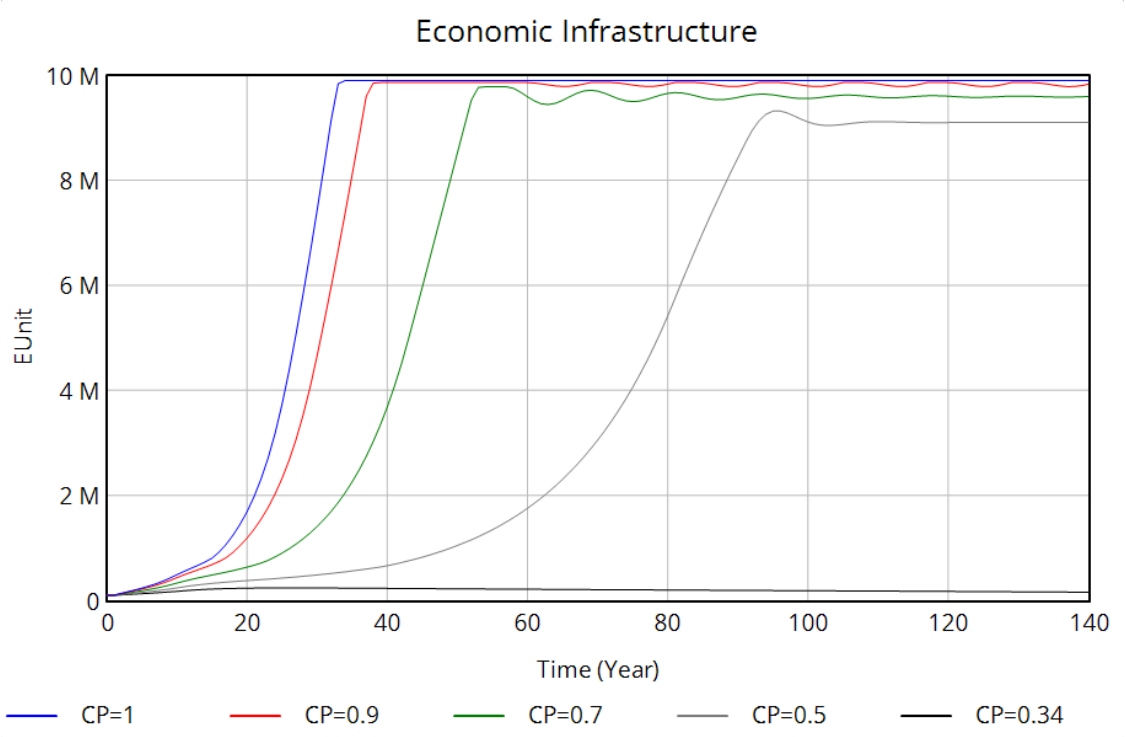
- All scenarios show declining numbers of unskilled workers from an initial 500M+ people, but at drastically different rates.
- Low corruption environments (CP=0.9-1) drive the fastest decline in unskilled workers, reducing to about 100M by year 100.
- High corruption (CP=0.34) preserves a large unskilled workforce, with over 250M remaining by year 140.
- This suggests corruption significantly impedes workforce development and skills training initiatives.

Education Infrastructure Graph



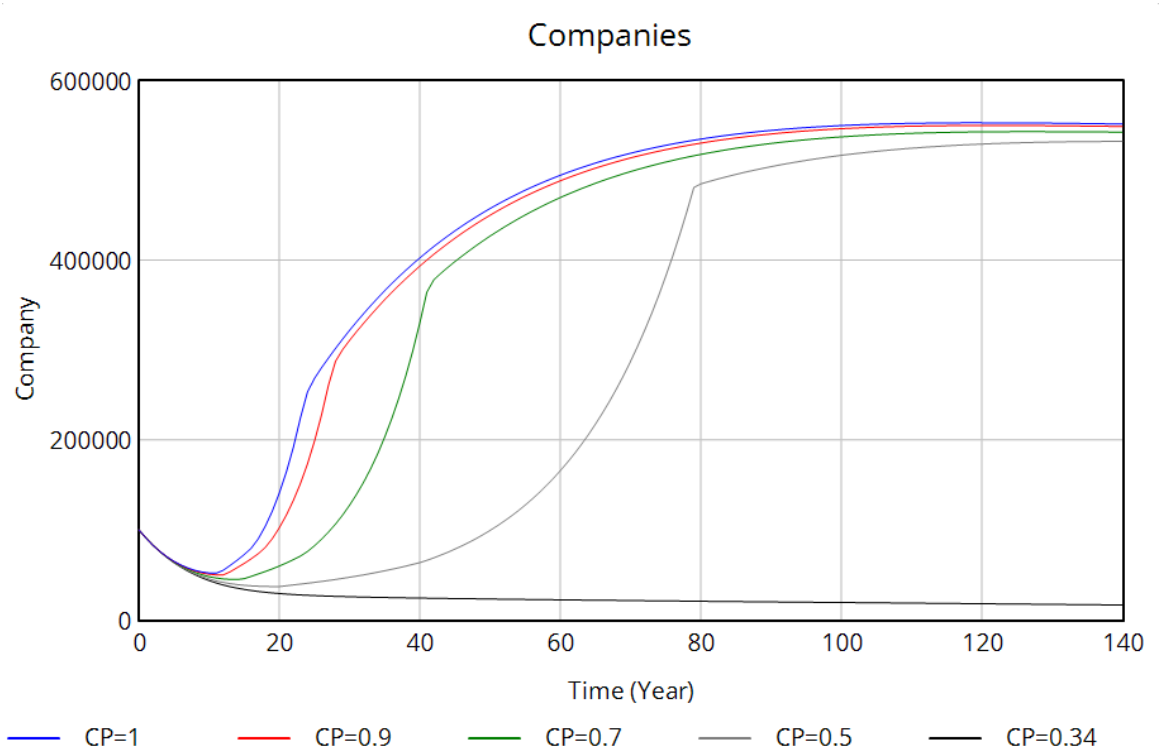
- All scenarios show initial growth followed by decline, not due to corruption effects but because of demographic transition - as total population growth slows, birth rates decline.
- The decline represents a natural response to decreasing studying population rather than institutional failure or sustainability issues.
- Low corruption environments (CP=0.9-1) achieve much higher peak educational infrastructure (around 700,000 institutions) before demographic effects cause contraction.
- High corruption (CP=0.34) severely limits the educational infrastructure potential, reaching only about 200,000 institutions at peak before demographic decline begins.

Economic Infrastructure Graph



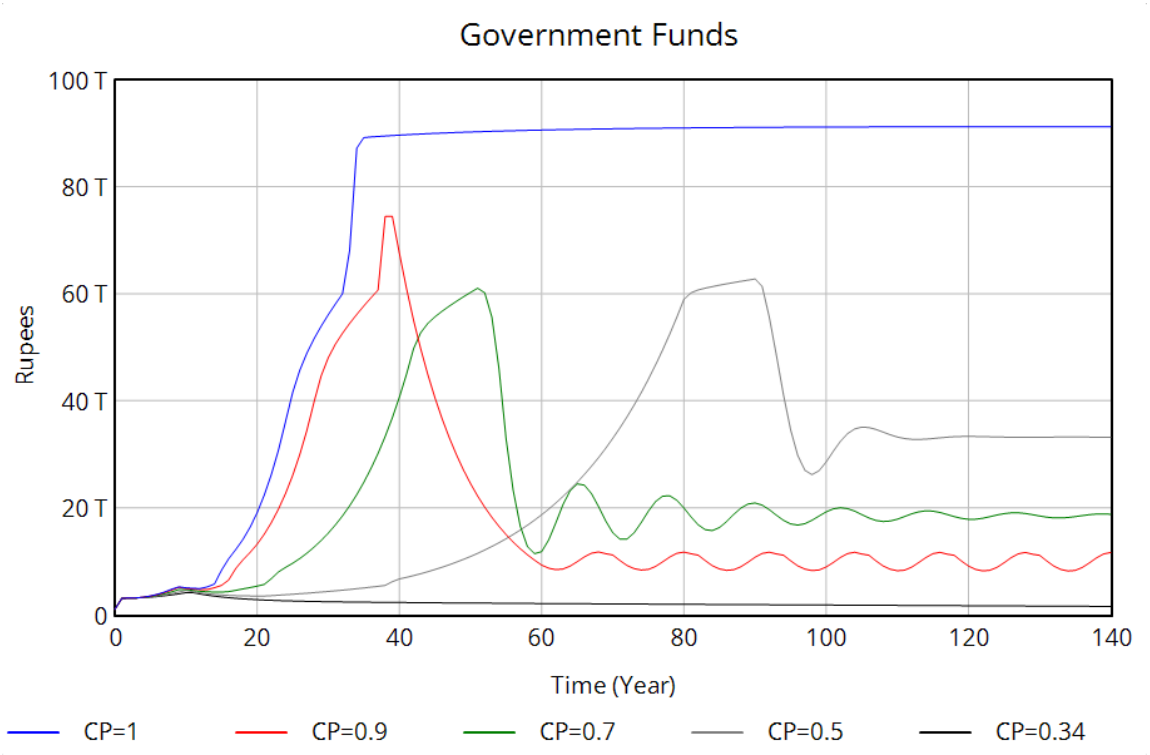
- Economic infrastructure development accelerates dramatically with less corruption, with CP=1 and CP=0.9 reaching 10M EUnits by year 40.
- More corrupt environments (CP=0.5-0.7) show significant delays in infrastructure development, taking up to 60-90 years to approach maximum levels.
- High corruption (CP=0.34) essentially prevents meaningful infrastructure development, with negligible growth over 140 years.
- The gap between high and low corruption scenarios is most dramatic in this graph, highlighting how corruption severely impedes economic infrastructure.

Companies Graph



- Low corruption scenarios (CP=0.9-1) facilitate rapid company growth, reaching approximately 550,000 companies by year 80.
- Moderate corruption (CP=0.5-0.7) shows delayed company growth, with CP=0.5 taking nearly twice as long to reach similar levels.
- High corruption (CP=0.34) prevents company growth almost entirely, with numbers remaining near initial levels throughout the simulation.
- Most scenarios eventually plateau, suggesting a carrying capacity for companies regardless of corruption levels.

Government Funds Graph



- With no corruption (CP=1), government funds grow rapidly and maintain stability at nearly 100T rupees without decline, as income tax collection remains efficient.
- In corrupt environments (CP<1), we observe eventual decline and fluctuations due to the model's income tax dynamics, which don't account for corruption directly.
- Higher corruption paradoxically shows more stability at lower fund levels because increased infrastructure degradation requires consistent government spending, creating a balancing effect.
- Corporate taxes (independent of expenditure) eventually balance the system in corrupt scenarios, creating equilibrium points that vary based on corruption levels.

Conclusion:

- Corruption causes delays in development projects, and it leads to more unemployment and social unrest.
- Threshold of collapse (66%) , if corruption is 66% or more then there will be inevitable collapse.
- If corruption happens then it will lead to less companies in the nation and less jobs.
- Dependence on a limited skilled workforce increases economic vulnerability.
- A skilled youth workforce is pivotal in transforming demographic potential into economic prosperity.
- A proficient workforce attracts businesses and increases entrepreneurship, driving economic growth.
- Strategic reforms targeting corruption and skill enhancement are essential to avert potential economic collapse.

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Appendix

All Previous Submissions can be found in this GitHub Link

SFD Model Details:

Population Dynamics

Sl No.	Name	Formula	Units
1	Studying Population	Birth Rate-No Skilling Rate-Skilling Rate	People
2	Skilled Workers	Skilling Rate+Upskill Rate-Skilled Youth Aging Rate	People
3	Unskilled Workers	No Skilling Rate-Unskilled Youth Aging Rate-Upskill Rate-Upskill Rate	People
4	Senior Citizens	Skilled Youth Aging Rate+Unskilled Youth Aging Rate-Death Rate	People
5	Birth Rate	Remaining Population Capacity Fraction*(Total Youth Population/2)*Pregnancy Rate	People/Year
6	Skilling Rate	"Studying Population (0 - 22)"*Fraction of Students Starting Work*Effect of Education Investment in Skilling	People/Year
7	No Skilling Rate	Fraction of Students Starting Work*"Studying Population (0 - 22)"*(1-Effect of Education Investment in Skilling)	People/Year
8	Skilled Youth Aging Rate	"Skilled Workers (23 - 59)"*Fraction of Workers Retiring	People/Year
9	Upskill Rate	Upskill Fraction*Effect of Education Investment in Skilling*"Unskilled Workers (23 - 59)"	People/Year
10	Unskilled Youth Aging Rate	"Unskilled Workers (23 - 59)"*Fraction of Workers Retiring	People/Year
11	Death Rate	"Senior Citizens (60+)"*Death Fraction	People/Year
12	Total Youth Population	"Skilled Workers (23 - 59)" + "Unskilled Workers (23 - 59)"	People
13	Total Population	"Studying Population (0 - 22)"+"Skilled Workers (23 - 59)"+"Unskilled Workers (23 - 59)"+"Senior Citizens (60+)"	People

14	Remaining Population Capacity Fraction	MAX(0, Population Fraction Adjustment-Total Population/Max Population Capacity)	People
15	Max Population Capacity	1.4e+09	People
16	Population Fraction Adjustment	1.4	Dmnl
17	Pregnancy Rate	0.06	1/Year
18	Fraction of Students Starting Work	1/23	1/Year
19	Upskill Fraction	0.001	People/Year
20	Fraction Workers Retiring	1/37	1/Year
21	Death Fraction	0.05	1/Year
22	Effect of Education Investment in Skilling	Education Limiting Factor*MIN(1, Education Infrastructure/Expected Education Infrastructure)	Dmnl
23	Expected Education Infrastructure	("Studying Population (0 - 22)"/Avg Students in an Education Institution)	Institution
24	Education Infrastructure	Education Development Rate-Education Degradation Rate	Institution
25	Education Limiting factor	0.8	Dmnl

Government Funds Dynamics

Sl No.	Name	Formula	Units
1	Government Funds	Income-Expenditure	Rupees
2	Income	Total Income Tax + Total Corporate Tax	Rupees/Year
3	Expenditure	MIN(Government Funds*Fund Adjustment Fraction, Mandatory Spending + Govt Investments + Corruption)	Rupees/Year
4	Avg Tax Paid by a Company	5e+06	Rupees/(Year*Company)
5	Avg Income of Taxpayers	1e+06	Rupees/People

6	Base Tax Rate	0.2	1/Year
7	Fund Adjustment Fraction	1	1/Year
8	Avg Spending on Welfare Schemes	1500	Rupees/(Year*People)
9	Avg Spending on Elderly Care	1500	Rupees/(Year*People)
10	Total Funds Needed	Economic Investment Needed+Education Investment Needed+Mandatory Spending-Total Corporate Tax	Rupees/Year
11	Expected Tax Rate	DELAY FIXED(Total Funds Needed/(Avg Income of Tax Payers*Income Tax Paying People), 1, 0.2)	1/Year
12	Tax Rate	MIN(Base Tax Rate, Expected Tax Rate)	1/Year
13	Total Corporate Tax	Companies*Avg Tax Paid by a Company	Rupees/Year
14	Total Income Tax	Tax Rate*Avg Income of Tax Payers*Income Tax Paying People	Rupees/Year
15	Income Tax Paying People	MIN(Skilled Jobs/Job to People Ratio,"Skilled Workers (23 - 59)")	People
16	Investment Budget	MAX(0,(Government Funds*Fund Adjustment Fraction)-Mandatory Spending)	Rupees/Year
17	Total Spending on Welfare Schemes	Avg Spending on Welfare Schemes*"Unskilled Workers (23 - 59)"	Rupees/Year
18	Mandatory Spending	Total Spending on Elderly Care + Total Spending on Welfare Schemes	Rupees/Year
19	Total Spending on Elderly Care	Avg Spending on Elderly Care*"Senior Citizens (60+)"	Rupees/Year
20	Govt Investments	Actual Economic Investment + Actual Education Investment	Rupees/Year
21	Corruption	Investment Budget*(1-Control Parameter)	Rupees/Year
22	Economic Investment Needed	Avg Economic Unit Cost*Economic Infrastructure Demand	Rupees/Year
23	Education Investment	Avg Education Institution	Rupees/Year

	Needed	Cost*Education Infrastructure Demand	
24	Companies	Company Formation-Company Closure	Company
25	Skilled Jobs	Job Fraction*"#Jobs"	Jobs
26	"Skilled Workers (23 - 59)"	Skilling Rate+Upskill Rate-Skilled Youth Aging Rate	People
27	Job to People Ratio	1	Jobs/People
28	"Unskilled Workers (23 - 59)"	No Skilling Rate-Unskilled Youth Aging Rate-Upskill Rate-Upskill Rate	People
29	"Senior Citizens (60+)"	Skilled Youth Aging Rate+Unskilled Youth Aging Rate-Death Rate	People
30	Actual Economic Investment	MIN(Economic Investment Budget, Economic Investment Needed)	Rupees/Year
31	Actual Education Investment	MIN(Education Investment Budget,Education Investment Needed)	Rupees/Year

Education Infrastructure Dynamics

Sl No.	Name	Formula	Units
1	Education Infrastructure	Education Development Rate-Education Degradation Rate	Institution
2	Education Development Rate	MIN(Education Infrastructure Demand,Education Infrastructure Supply)	Institution/Year
3	Education Degradation Rate	Education Degradation Fraction*Education Infrastructure	Institution/Year
4	Education to Economic Fraction Ratio	1	Dmnl
5	Avg Education Institution Cost	3e+07	Rupees/Institution
6	Edu Infra Adjustment Fraction	1	1/Year
7	Avg Students in an Education Institution	400	People/Institution
8	Max Education Degradation Rate	0.05	1/Year

9	Min Education Degradation Rate	0.01	1/Year
10	Education Degradation Fraction	Max Education Degradation Rate-((Max Education Degradation Rate-Min Education Degradation Rate)*Control Parameter)	1/Year
11	Education Investment Fraction	1/(1+1/Education to Economic Fraction Ratio)	Dmnl
12	Actual Education Investment	MIN(Education Investment Budget,Education Investment Needed)	Rupees/Year
13	Education Investment Budget	Control Parameter*Education Investment Fraction*Investment Budget	Rupees/Year
14	Education Infrastructure Supply	Education Investment Budget/Avg Education Institution Cost	Institution/Year
15	Education Investment Needed	Avg Education Institution Cost*Education Infrastructure Demand	Rupees/Year
16	Education Infrastructure Demand	Education Infrastructure*Remaining Education Infrastructure Demand*Edu Infra Adjustment Fraction	Institution/Year
17	Expected Education Infrastructure	("Studying Population (0 - 22)"/Avg Students in an Education Institution)	Institution
18	Remaining Education Infrastructure Demand	MAX(0, 1-Education Infrastructure/Expected Education Infrastructure)	Dmnl
19	Investment Budget	MAX(0,(Government Funds*Fund Adjustment Fraction)-Mandatory Spending)	Rupees/Year
20	"Studying Population (0 - 22)"	Birth Rate-No Skilling Rate-Skilling Rate	People

Economic Infrastructure Dynamics

Sl No.	Name	Formula	Units
1	Economic Infrastructure	Economic Development Rate-Economic Degradation Rate	EUnit
2	Economic Development Rate	MIN(Economic Infrastructure Demand, Economic Infrastructure Supply)	EUnit/Year
3	Economic Degradation Rate	Economic Degradation Fraction*Economic Infrastructure	EUnit/Year

4	Avg Economic Unit Cost	3e+07	Rupees/EUnit
5	Eco Infra Adjustment Fraction	1	1/Year
6	Max Capacity of Economic Infrastructure	1e+07	EUnit
7	Max Economic Degradation Fraction	0.05	1/Year
8	Min Economic Degradation Fraction	0.01	1/Year
9	Economic Degradation Fraction	Max Economic Degradation Fraction-((Max Economic Degradation Fraction-Min Economic Degradation Fraction)*Control Parameter)	1/Year
10	Economic Investment Fraction	1/(1+Education to Economic Fraction Ratio)	Dmnl
11	Actual Economic Investment	MIN(Economic Investment Budget, Economic Investment Needed)	Rupees/Year
12	Economic Investment Budget	Control Parameter*Economic Investment Fraction*Investment Budget	Rupees/Year
13	Economic Infrastructure Supply	Economic Investment Budget/Avg Economic Unit Cost	EUnit/Year
14	Economic Investment Needed	Avg Economic Unit Cost*Economic Infrastructure Demand	Rupees/Year
15	Economic Infrastructure Demand	Economic Infrastructure*Remaining Economic Infrastructure Capacity*Eco Infra Adjustment Fraction	EUnit/Year
16	Remaining Economic Infrastructure Capacity	MAX(0, 1-Economic Infrastructure/Max Capacity of Economic Infrastructure)	Dmnl
17	Education to Economic Fraction Ratio	1	Dmnl
18	Investment Budget	MAX(0,(Government Funds*Fund Adjustment Fraction)-Mandatory Spending)	Rupees/Year

Company Dynamics

Sl No.	Name	Formula	Units
1	Companies	Company Formation-Company Closure	Company
2	Company Formation	Remaining Company Capacity*Companies*Company Adjustment Fraction	Company/Year
3	Company Closure	MAX(0, Companies-Sustainable Company Capacity)*Bankruptcy Rate	Company/Year
4	Company Adjustment Fraction	1	1/Year
5	Avg Economic Infrastructure Requirement for a Company	10	EUnit/Company
6	Avg Workforce Requirement per Company	500	People/Company
7	Bankruptcy Rate	0.1	1/Year
8	Sustainable Company Capacity	MIN(Economic Infrastructure/Avg Economic Infrastructure Requirement for a Company, (Skilled Weightage*"Skilled Workers (23 - 59)"+(1-Skilled Weightage)*"Unskilled Workers (23 - 59)")/Avg Workforce Requirement per Company)	Company
9	Skilled Weightage	0.99	Dmnl
10	Remaining Company Capacity	MAX(0, 1-Companies/Sustainable Company Capacity)	Dmnl
11	Job to People Ratio	1	Jobs/People
12	"#Jobs"	Companies*Avg Workforce Requirement per Company*Job to People Ratio	Jobs
13	Unskilled Jobs	(1-Job Fraction)*"#Jobs"	Jobs
14	Job Fraction	0.9	Dmnl
15	Skilled Jobs	Job Fraction*"#Jobs"	Jobs
16	Percentage Adjustment	100	Percentage

17	Unemployment	(("Skilled Workers (23 - 59)"+"Unskilled Workers (23 - 59)" - (MIN("Skilled Workers (23 - 59)",Skilled Jobs/Job to People Ratio) + MIN("Unskilled Workers (23 - 59)",Unskilled Jobs/Job to People Ratio)))/("Skilled Workers (23 - 59)" + "Unskilled Workers (23 - 59)"))*Percentage Adjustment	Percentage
18	"Unskilled Workers (23 - 59)"	No Skilling Rate-Unskilled Youth Aging Rate-Upskill Rate-Upskill Rate	People
19	Economic Infrastructure	Economic Development Rate-Economic Degradation Rate	EUnit
20	"Skilled Workers (23 - 59)"	Skilling Rate+Upskill Rate-Skilled Youth Aging Rate	People