Divergence in Economic Output, Convergence in Human Development:

A simple 2-region model of production with migration dynamics

By

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Abstract:

The literature of economic growth focuses mainly on nation/country as the unit of economic analysis. However, the dynamics of growth and development inside a country do not necessarily follow parallel paths. For example, states within India have slowly converged on human development indicators even as there is divergence in per-capita output. In this study, I develop a simple two-region model of production to study the variation in trends of economic output (aggregate as well as per-capita), when labor migration between regions is possible. The model suggests that convergence in human capital indicators does not lead to convergence in economic output, when there is an initial difference in human capital and productivity. It also shows that convergence is possible when the productivity growth shock to the poor state is large compared to the shock to the richer state. Additionally, I use different combinations of shocks in my simulations to show varying economic trends depending on whether the two states start off with same or different amount of resources.

Introduction:

For the past decade, India has been considered a 'bright spot' in a tumultuous world economy, with particular reference to growth in national GDP figures.[1] These commentaries offer little insight into the disaggregated, or regional, developments - which present a much more humbling perspective.

Despite the importance of union governments, many national policies play out at the level of individual states. Hence, the effects of changing nationally economic policy have different results in different regions, especially after economic liberalization, which had resulted in a greater role for state level policy initiatives.[2] It is, therefore, worthwhile to analyze the disparities in income levels of different states that constitute this national economy.

Research has shown that the rich states have become richer while poorer states remained poor (see figure A1). Private and public investment as well has FDI have also gravitated to richer states. (see figure A2, A3). There is a trap that has reinforced itself over time i.e. states beginning with low per-capita income have low investment and hence, low output. This was less so pre-1990s but has worsened post-liberalization with progressively lesser intervention by state in economic activities. In general, western and southern states have fared much better than northern and eastern states.

At the same time, indicators of human development like literacy rate, male-female literacy gap, life expectancy at birth, infant mortality ratio, total fertility rate have converged significantly since 1950s. (see figure A4-5) A possible channel of this convergence could be through inter-regional transfers by the federal government or through private contributions from NGOs which can be a mitigating factor in economic output.

Another interesting phenomenon we observe is the migration of people from poorer states to richer states over time (see figure A6). It is the impact of this migration on economic outcomes that I shed some light on, in this study. To illustrate this phenomenon of divergence in economic output and convergence in human development indicators, I develop a simple two-region model of production across multiple time periods with migration between the regions in both directions.

Model:

Now I describe the model in detail:

Consider 2 states (A, B) within a country for two time periods $t = (t_1), (t_2)$ for simplicity, to begin with (I will further extend the model over multiple periods). Assume that labor can move within the country i.e. between states if it is willing and able. Only a very small fraction of the total population own capital, so a movement of labor from one state to another has no implication for mobility of capital. What this means is that only wage-earners migrate.

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[1] URL: https://blogs.worldbank.org/endpovertyinsouthasia/india-s-remarkably-robust-and-resilient-growth-story

[2] URL: http://journals.openedition.org/regulation/10247

First, I define the production function of each state in time period 1:

At t = (t_1), from the human capital augmented Solow growth model (Hall and Jones, 1999), I can write the production function in standard Cobb-Douglas form as:

$$Y_A(t_1) = \left(A_A(t_1).H_A(t_1)\,L_A(t_1)\right)^{\alpha}.K_A^{\beta}(t_1)$$

$$Y_{\boldsymbol{B}}(t_1) = (A_B(t_1).H_B(t_1)L_B(t_1))^{\alpha}\,.K_B^{\beta}(t_1)$$

where $\alpha + \beta = 1$, A represents the state of technology in the state, L represents the population of the state, K represents the stock of physical capital in the state, H represents the stock of human capital in the state (assuming that everyone in once state has identical human capital) and is given by the equation:

$$H_A = f(E_A) = \ b.(1 - \exp(-\,\lambda.E_A))$$

$$H_B = f(E_b) = \ b.(1 - \exp(-\lambda.E_B))$$

where E is the average number of years of schooling of people in the state, b is the maximum number of years of schooling possible for the labor force, λ is the speed at which the human capital increases with years of schooling. This functional form of human capital ensures that human capital increases as years of schooling increases but is bounded by b.

Given this functional form of human capital, I can write

$$f^{-1}(H) = \frac{1}{\lambda}\log\left(\frac{b}{b-H}\right)$$

At the same time, in period 1,

the average wage earned by someone in state A is $w_A = \alpha.\frac{Y_A(t_1)}{L_A(t_1)}$, and

the average wage earned by someone in state B is $w_B = \alpha.\frac{Y_B(t_1)}{L_B(t_1)}$

Also, the wages w_i of individuals are distributed log-normally for both states such that the probability distribution function of $\log w_i$ is given as:

$$g(\log w_i) = \frac{1}{\sqrt{2\pi\sigma^2}}\exp\left(-\frac{1}{2\sigma^2}(\log w_i - \mu)^2\right)$$

with a mean wage $\overline{w}$ of $\exp\left(\mu + \frac{\sigma^2}{2}\right)$.

Now I provide a description of migration dynamics:

In period t_1, migrants compare migration cost with expected future returns from migrating to the other state in the period (t_2). It is only the differences in the labor income i.e. wage w that creates incentives for inter-state migration. Of course, there are migration costs which serve as disincentives.

A potential migrant from state A enters state B at (t_2) if the expected benefit from migration exceeds the costs of migrations. I define expected benefit of migration at the end of period (t_1), $D_i(t_1)$, as the present value of the difference in their current wage in state A and the current average wage in state B. I assume that migrants make their decision in the belief that this current difference in wage persists into the second period. It is given by:

$$D_i(t_1) = \frac{\overline{w}_B(t_1) - w_{iA}(t_1)}{1 + r}$$

where $\overline{w}_B$ is the average wage in state B, $w_{iA}(t_1)$ is the wage that the potential migrant earns today in state A, r is the discount rate

The total cost of migration is the sum of the cost of moving from one place to another and the cost of setting up in a new place. I assume the cost of travelling to be fixed while the cost of setting up in a new place to be a fixed fraction of their wage in the destination state, if they migrate. Therefore, the total migration cost $c_m(t_1) = \theta * \overline{w}_B(t_1)$, some fixed fraction θ of the wages earned by the people in state B.

This migration cost, therefore, is also log-normally distributed in wages of state B.

Potential migrants in state A migrate if they perceive the benefit from migration $D_i(t_1)$ to be greater than the cost of migration $c_m(t_1)$ i.e.

$$D_i(t_1) \geq c_m(t_1)$$

From these equations and distributions, we can find out the number of migrants for whom migration is more beneficial compared to the costs, i.e. $D_i(t_1) \geq c_m(t_1)$ and get $M_{AB}(t_1) = x.L_A(t_1)$ where x is the fraction of the total population of state A that migrates.

$$M_{AB}(t_1) = \sum 1_{\overline{\mathrm{w}}_\mathrm{B}} \left(w_{iA}(t_1)\right)$$

where

$$1_{\overline{\mathrm{w}}_\mathrm{B}} \left(w_{iA}(t_1)\right) = \begin{cases} 0\,;\ w_{iA}(t_1) > \ \overline{w}_B(t_1)[1 - (1 + r) * \theta] \\ 1\,;\ w_{iA}(t_1) < \ \overline{w}_B(t_1)[1 - (1 + r) * \theta] \end{cases}$$

Similarly, I find the $M_{BA}(t_1)$ i.e. the number of migrant from state B to state A at the end of period (t_1). Thereafter, I define the production function of each state in time period 2. To do that, I first define the different components of the production function.

So, in period (t_2), the labor supply in the two states can be characterized as follows:

$$L_A(t_2) = (1+n).L_A(t_1) - M_{AB} + M_{BA}$$

$$L_B(t_2) = (1+n).L_B(t_1) + M_{AB} + M_{BA}$$

where n represents the population growth rate in the states which I have assumed, for simplicity, to be the same for the two states.

In period (t_2), the technology in the two states can be characterized as follows:

$$A_A(t_2) = (1+g+\epsilon_A).A_A(t_1)$$

$$A_B(t_2) = (1+g+\epsilon_A).A_B(t_1)$$

where g is the growth rate of technology in the two states which I have assumed, for simplicity, to be the same for the two states, and ϵ is the positive random shock to g of the states.

The stock of physical capital in the two states in period (t_2) can be characterized as follows:

$$K_A(t_2) = s.Y_A(t_1) + (1-\delta).K_A(t_1)$$

$$K_B(t_2) = s.Y_B(t_1) + (1-\delta).K_B(t_1)$$

where s represents the savings rate, δ represents the rate of capital depreciation, assuming that the rates are same across states.

As mentioned earlier, the movement of labor has no bearing on the movement of capital because there are very few capital owners and they do not move.

Suppose, the human capital increases over time in the following manner:

$$H_A(t_2) = b.\left(1 - \exp\left(-\lambda\left(f^{-1}\left(H_A(t_1) + q.w_A(t_1)\right)\right)\right)\right)$$

$$= b.(1 - \exp\left(-\lambda\left(\frac{1}{\lambda}.\log\left(\frac{b}{b - H_A(t_1)}\right) + q.w_A(t_1)\right)\right))$$

Similarly, $$H_B(t_2) = b.(1 - \exp\left(-\lambda\left(\frac{1}{\lambda}.\log\left(\frac{b}{b-H_B(t_1)}\right) + q.w_B(t_1)\right)\right))$$

where q is a parameter.

Hence, the production function of the two states in the period (t_2) can be characterized using the aforementioned values as:

$$Y_A(t_2) = \left(A_A(t_2).H_A(t_2)\ L_A(t_2)\right)^{\alpha}.K_A^{\beta}(t_2)$$

$$Y_{\boldsymbol{B}}(t_2) = (A_B(t_2).H_B(t_2)L_B(t_2))^{\alpha}.K_B^{\beta}(t_2)$$

This process repeats in the next period and so on.

Results:

I simulated the evolution of variables for 40 periods in 50 replications for the following 8 cases:

1. States begin with same values of $A(0)$ and of $H(0)$ and they receive equal positive productivity shocks $\epsilon_A = \epsilon_B = abs(\epsilon),\ \epsilon \sim N(0.01, 0.005)$
2. States begin with same values of $A(0)$ and of $H(0)$ and receive unequal positive productivity shocks such that $\epsilon_B = 0.01, \epsilon_A = abs(\epsilon),\ \epsilon \sim N(0.01, 0.005)$
3. States begin with same values of $A(0)$ and $H_A(0) < H_B(0)$ and they receive equal positive productivity shocks $\epsilon_A = \epsilon_B = abs(\epsilon),\ \epsilon \sim N(0.01, 0.005)$
4. States begin with same values of $A(0)$ and $H_A(0) < H_B(0)$and they receive equal positive productivity shocks $\epsilon_B = 0.01, \epsilon_A = abs(\epsilon),\ \epsilon \sim N(0.01, 0.005)$
5. States begin with same values of $A(0)$ and $H_A(0) < H_B(0)$and they receive equal positive productivity shocks $\epsilon_A = 0.01, \epsilon_B = abs(\epsilon),\ \epsilon \sim N(0.01, 0.005)$
6. States begin with different values of $A(0), A_A(0) < A_B(0)$, $H_A(0) < H_B(0)$ and they receive equal positive productivity shocks $\epsilon_A = \epsilon_B = abs(\epsilon),\ \epsilon \sim N(0.01, 0.005)$
7. States begin with different values of $A(0), A_A(0) < A_B(0)$, $H_A(0) < H_B(0)$and only A receives positive productivity shocks $\epsilon_B = 0,\ \epsilon_A = abs(\epsilon),\ \epsilon \sim N(0.01, 0.005)$

In all my simulations, both states start with the same value for the stock of labor ($L(0) =$ 100,000), physical capital ($K(0) =$ 100,000) and parameters like $\alpha(= 0.67), \beta(= 0.33), n(=$ 0.02), $g(= 0.02), s(= 0.02), \delta(= 0.01), r(= 0.05)$.

In cases 1-2, $A_A(0) = A_B(0) = 40, H_A(0) = H_B(0) \approx 8$

In cases 3-5, $A_A(0) = A_B(0) = 40, H_A(0) \approx 8, H_B(0) \approx 9.5$

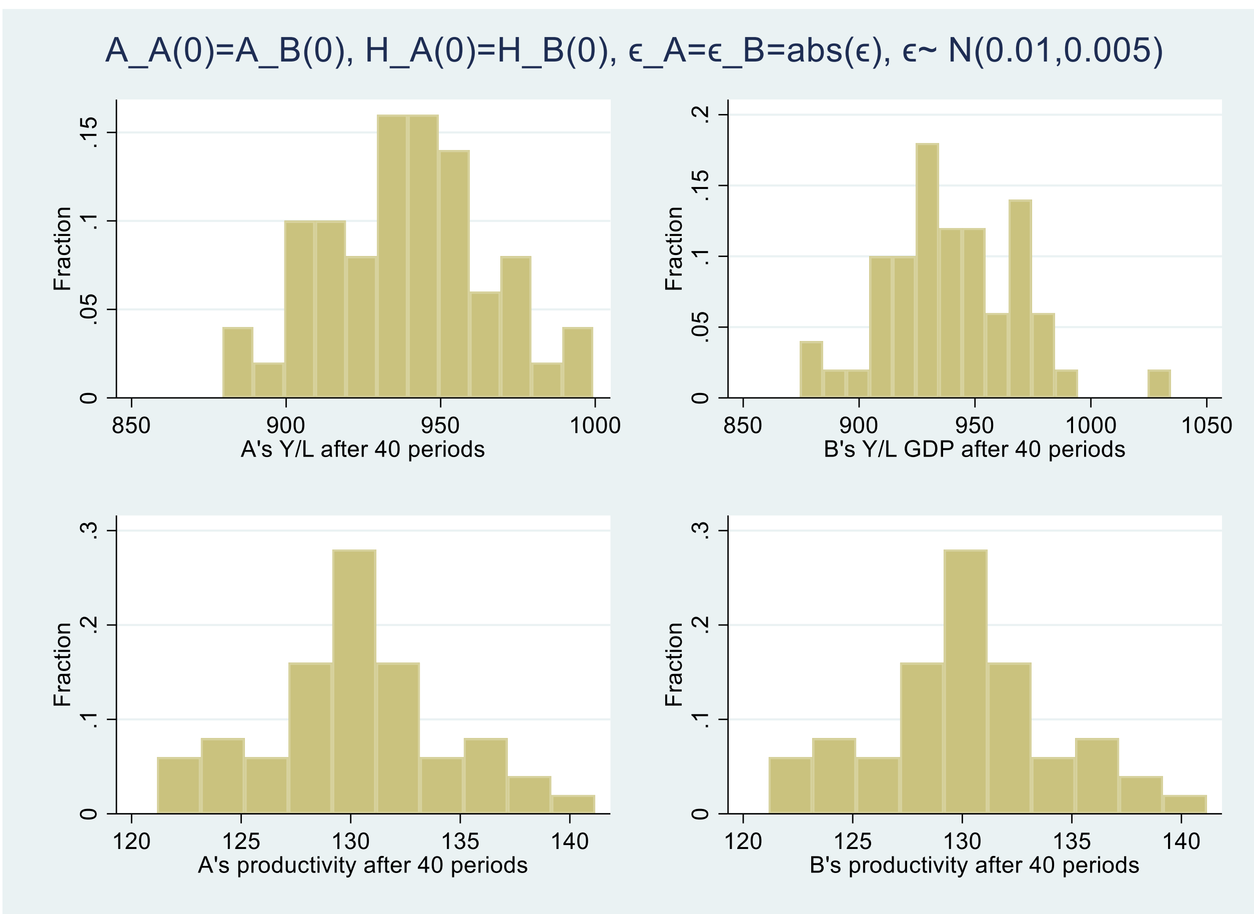
In cases 6-7, $A_A(0) = 40, A_B(0) = 50, H_A(0) \approx 8, H_B(0) \approx 9.5$

1. Here are the results when both states begin with same values of $A(0)$ and of $H(0)$ $\epsilon_A = \epsilon_B = abs(\epsilon),\ \epsilon \sim N(0.01, 0.005)$

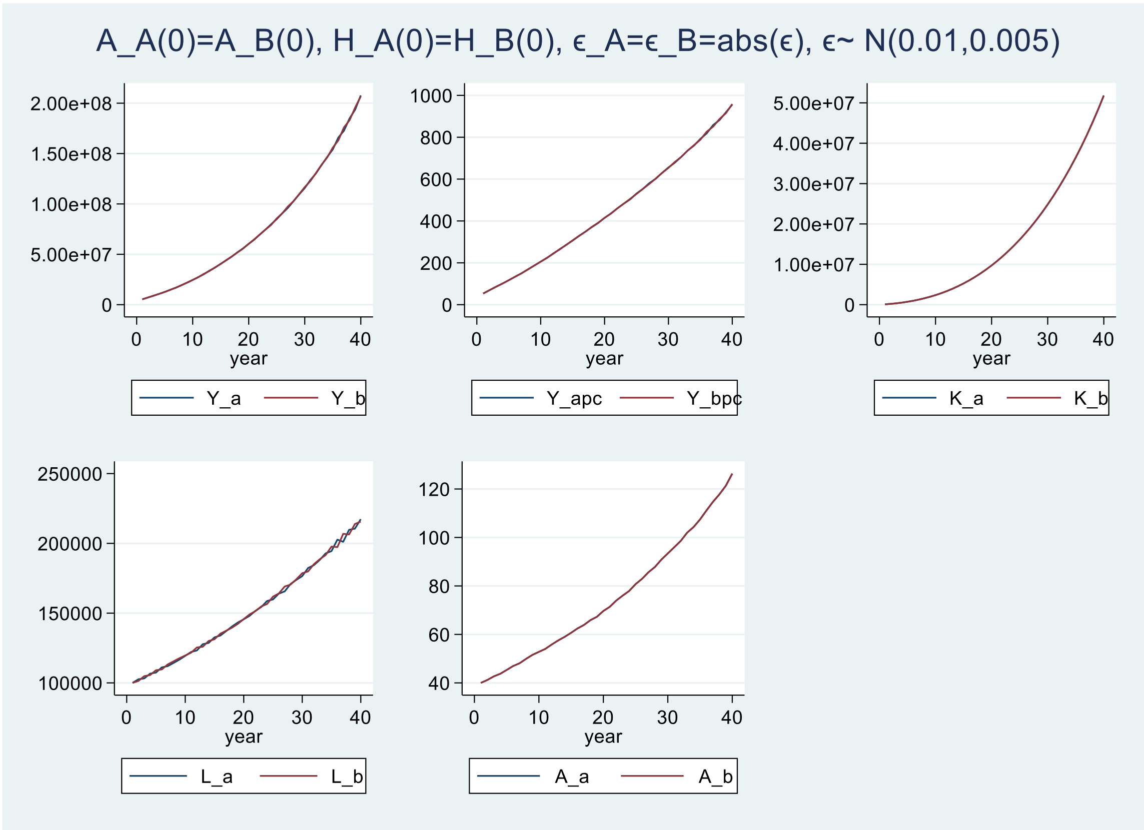
The following table shows the summary statistics of per-capita output (y), human capital (average years of schooling, h) and productivity(A) in the two states at the end of 40 periods:

Variable	Obs	Mean	Std. Dev.	Min	Max
y_a	50	939.149	27.19924	879.3698	996.6213
y_b	50	940.4623	29.20678	874.4716	1031.881
h_a	50	14.99997	8.29e-06	14.99995	14.99998
h_b	50	14.99997	8.33e-06	14.99995	14.99998
A_a	50	130.2134	4.187375	121.1588	141.0909
A_b	50	130.2134	4.187375	121.1588	141.0909

The following histogram shows the distribution of per-capital output and of productivity in the two states at the end of 40 periods:



The following graphs show the evolution of economic indicators (aggregate output Y, per-capital output Y_pc, capital K, labor L, productivity A) for both the states over 40 years for one simulation:



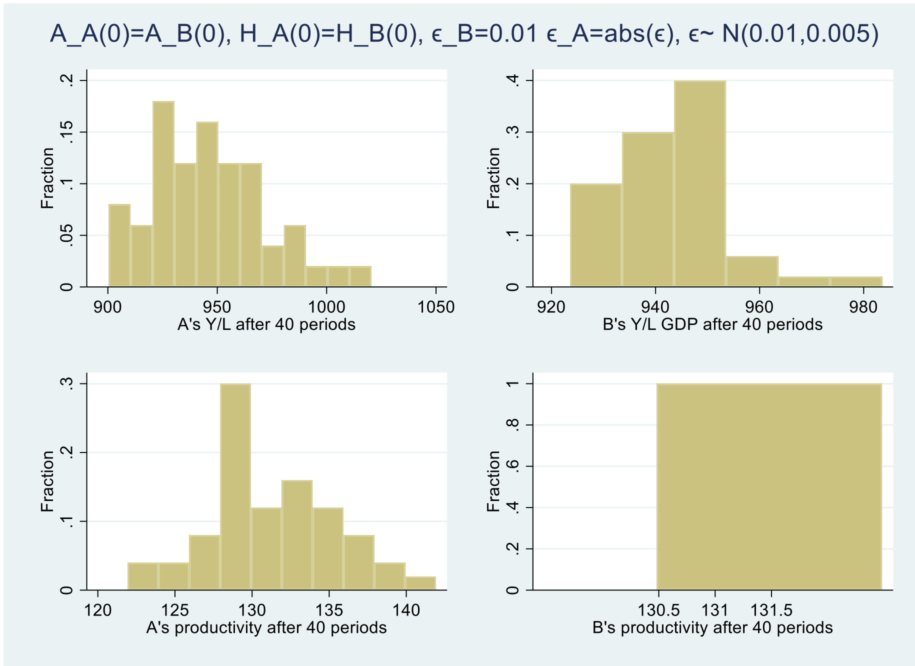
We can see from above chart that when both states begin with same values of $A(0)$ and of $H(0)$, equal positive shocks to the productivity growth lead to no significant differences in aggregate output as well as per-capita output between the two states. Even when $\epsilon_A \neq \epsilon_B = abs(\epsilon),\ \epsilon \sim N(0.01, 0.005)$, I get very similar results.

2. Here are the results when both states begin with same values of $A(0)$ and of $H(0)$ but $\epsilon_A = abs(\epsilon),\ \epsilon \sim N(0.01, 0.005), \epsilon_B = 0.01$

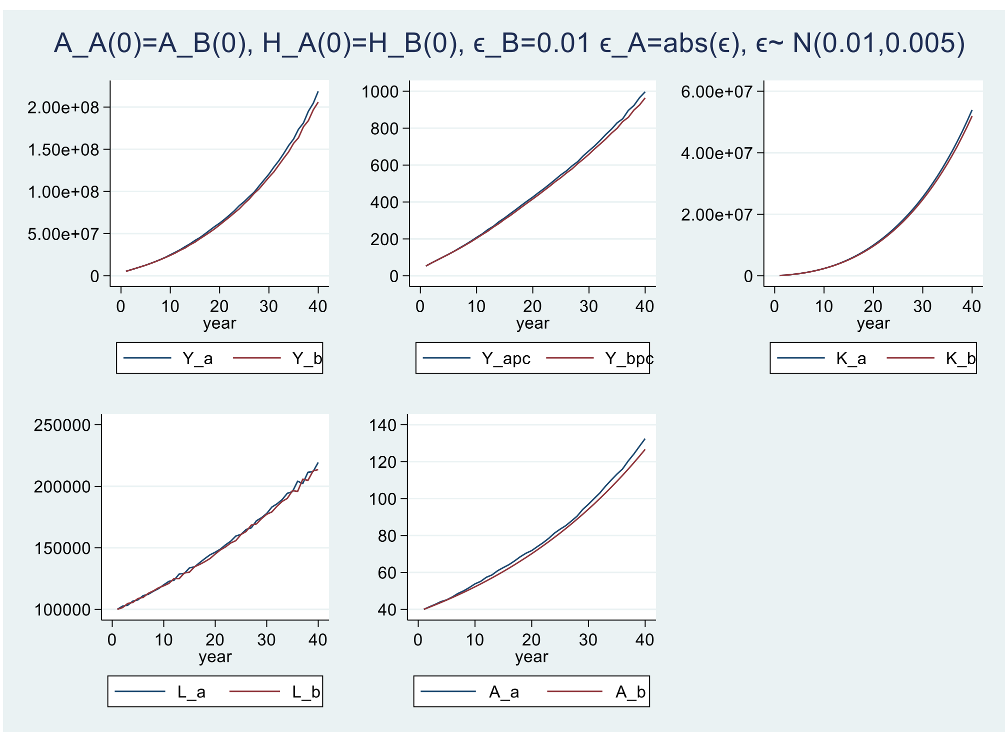
The following table shows the summary statistics of per-capita output (y), human capital (average years of schooling, h) and productivity(A) in the two states at the end of 40 periods:

Variable	Obs	Mean	Std. Dev.	Min	Max
y_a	50	946.0021	26.22924	900.4166	1015.626
y_b	50	943.0267	10.35101	923.5503	973.7164
h_a	50	14.99997	6.88e-06	14.99996	14.99998
h_b	50	14.99997	4.68e-07	14.99997	14.99997
A_a	50	131.2307	3.964718	121.9296	141.3815
A_b	50	130.4815	0	130.4815	130.4815

The following histogram shows the distribution of per-capital output in the two states at the end of 40 periods:



The following graphs show the evolution of economic indicators (aggregate output Y, per-capital output Y_pc, capital K, labor L, productivity A) for both the states over 40 years for one simulation:



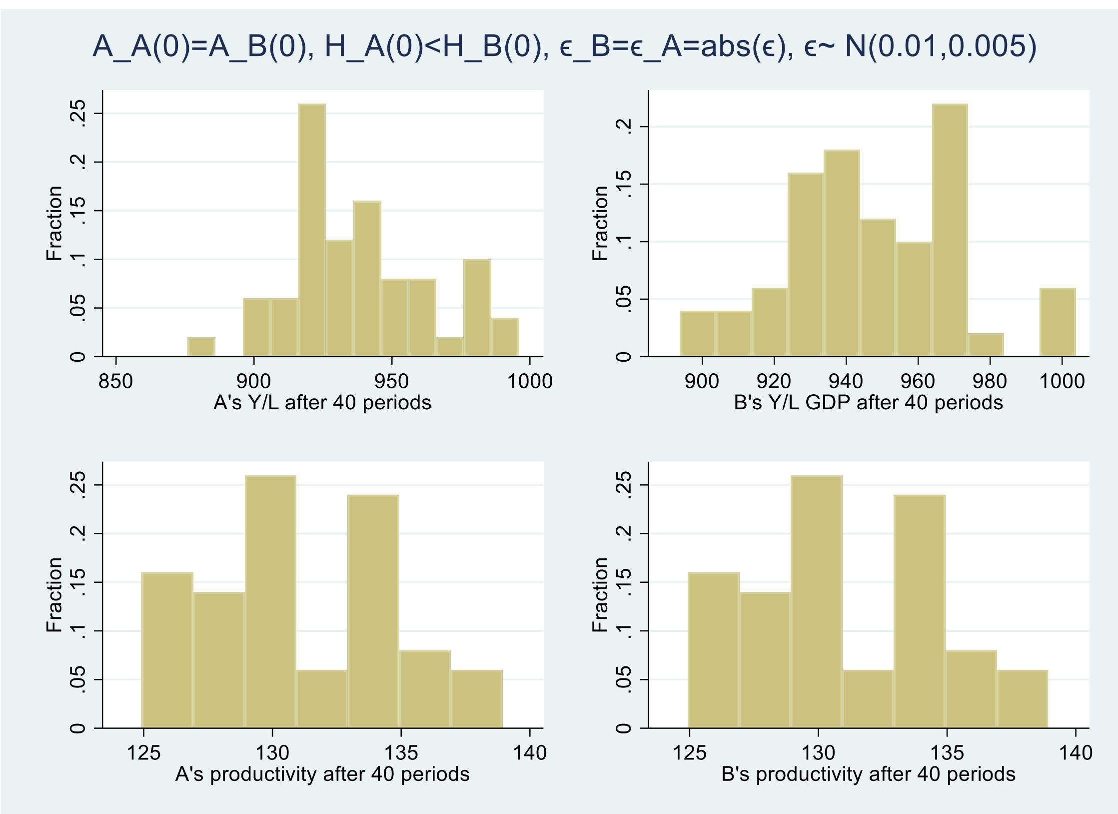
We can see from above chart that when both states begin with same values of $A(0)$ and of $H(0)$, when A receives a positive random shock and B receives a fixed positive shock to the productivity growth, it leads to small but gradual divergence in aggregate output as well as per-capita output between the two states with A's economic indicator always better off.

3. Here are the results when both states begin with same values of $A(0)$ and $H_A(0) < H_B(0)$, $\epsilon_A = \epsilon_B = abs(\epsilon)$, $\epsilon \sim N(0.01, 0.005)$

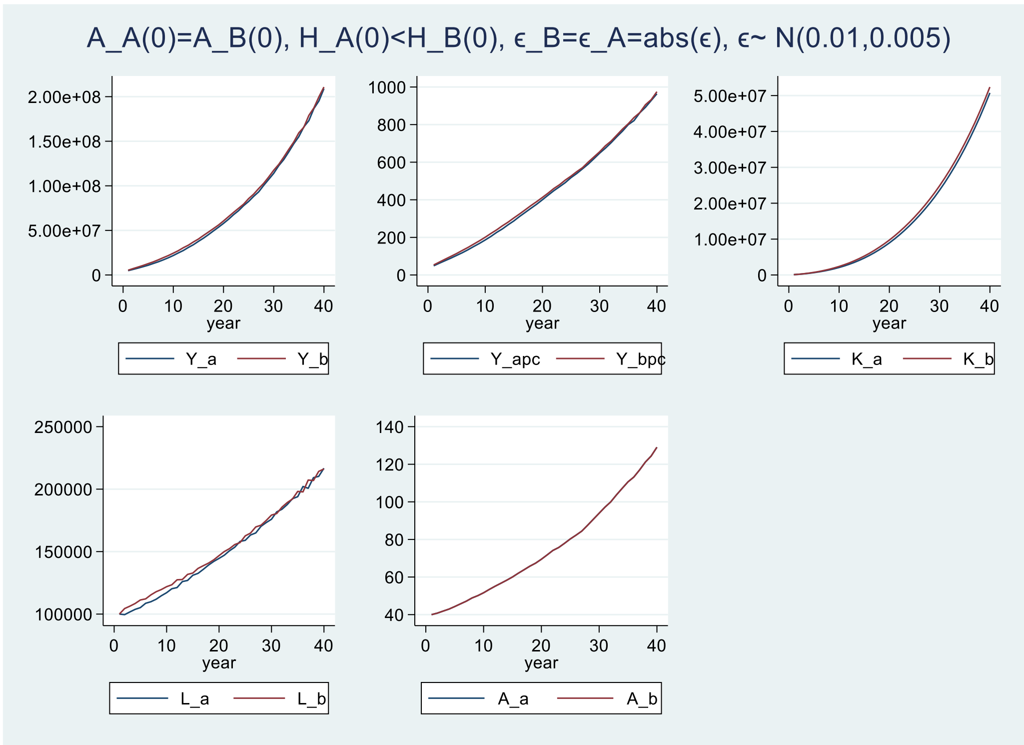
The following table shows the summary statistics of per-capita output (y), human capital (average years of schooling, h) and productivity(A) in the two states at the end of 40 periods:

Variable	Obs	Mean	Std. Dev.	Min	Max
y_a	50	937.8086	25.78296	875.9854	994.2791
y_b	50	947.3416	23.95174	893.806	998.7669
h_a	50	14.99995	.0000107	14.99993	14.99998
h_b	50	14.99997	6.65e-06	14.99996	14.99998
A_a	50	131.0428	3.453909	124.927	138.4434
A_b	50	131.0428	3.453909	124.927	138.4434

The following histogram shows the distribution of per-capita output and productivity in the two states at the end of 40 periods:



The following graphs show the evolution of economic indicators (aggregate output Y, per-capital output Y_pc, capital K, labor L, productivity A) for both the states over 40 years for one simulation:



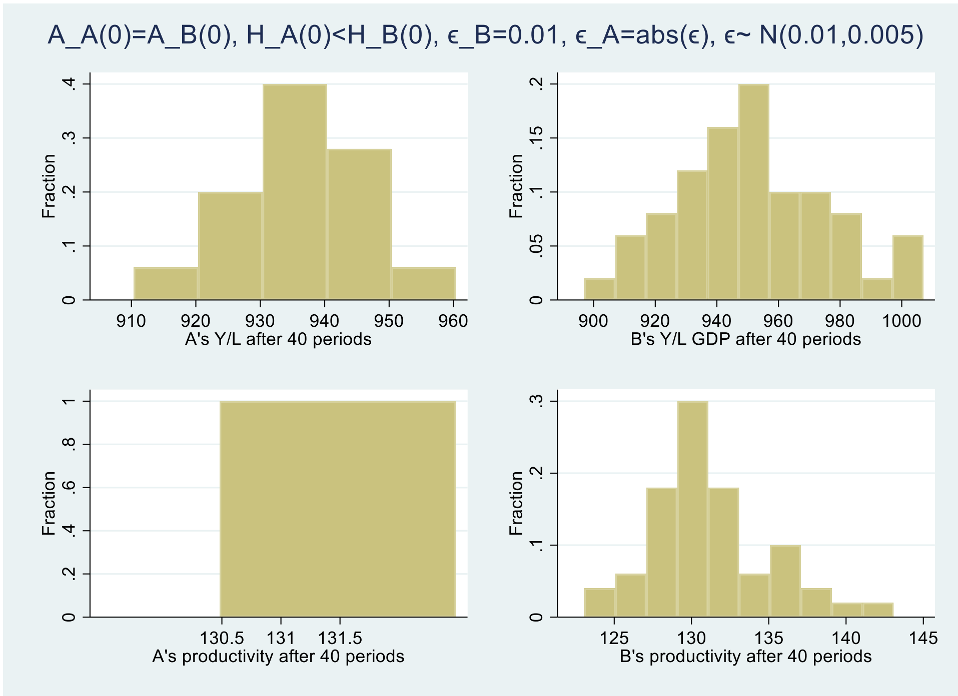
We can see from above chart that when both states begin with same values of $A(0)$ and different $H(0)$, and receive equal positive random shocks to the productivity growth, there is no divergence in aggregate output as well as per-capita output between the two states. If the only difference between the two states is human capital and it caches up over time, both states follow similar economic paths. I also get very similar results when the shocks are characterized as: $\epsilon_A \neq \epsilon_B, abs(\epsilon),\ \epsilon \sim N(0.01, 0.005)$

4. Here are the results when both states begin with same values of $A(0)$ and $H_A(0) < H_B(0), \epsilon_B = 0.01, \epsilon_A = abs(\epsilon),\ \epsilon \sim N(0.01, 0.005)$

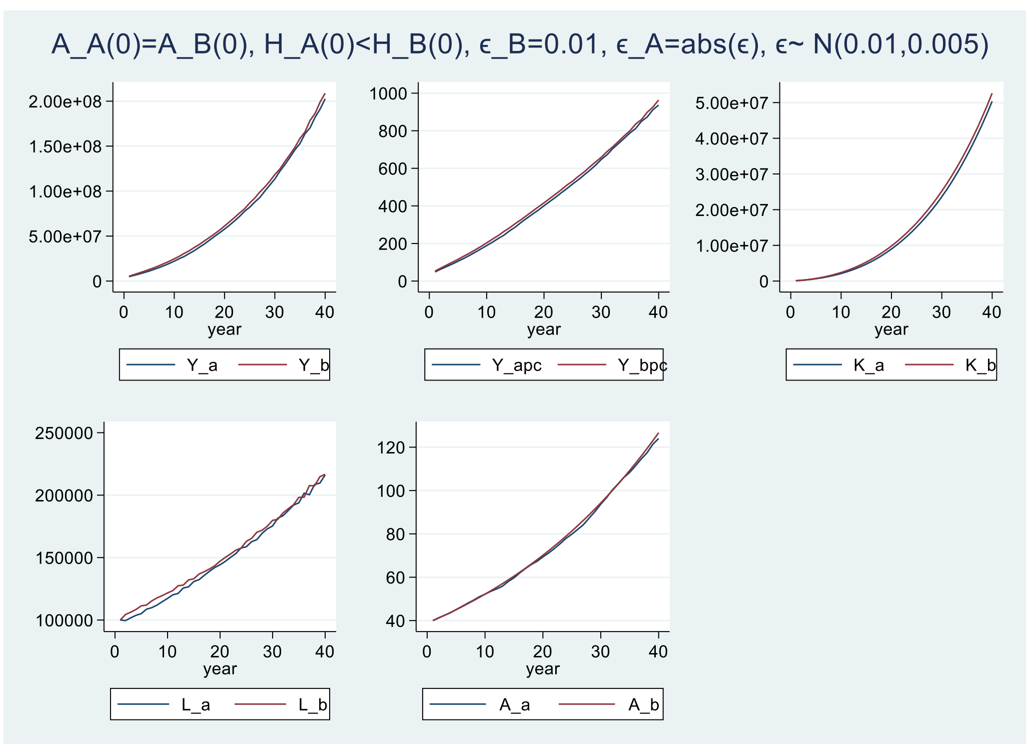
The following table shows the summary statistics of per-capita output (y), human capital (average years of schooling, h) and productivity(A) in the two states at the end of 40 periods:

Variable	Obs	Mean	Std. Dev.	Min	Max
y_a	50	942.7864	29.44206	883.3964	1015.587
y_b	50	944.8182	10.14911	925.1984	976.2205
h_a	50	14.99995	.0000117	14.99992	14.99997
h_b	50	14.99997	2.35e-07	14.99997	14.99997
A_a	50	131.783	4.156374	122.5225	141.5153
A_b	50	130.4815	0	130.4815	130.4815

The following histogram shows the distribution of per-capital output and of productivity in the two states at the end of 40 periods:



The following graphs show the evolution of economic indicators (aggregate output Y, per-capital output Y_pc, capital K, labor L, productivity A) for both the states over 40 years for one simulation:



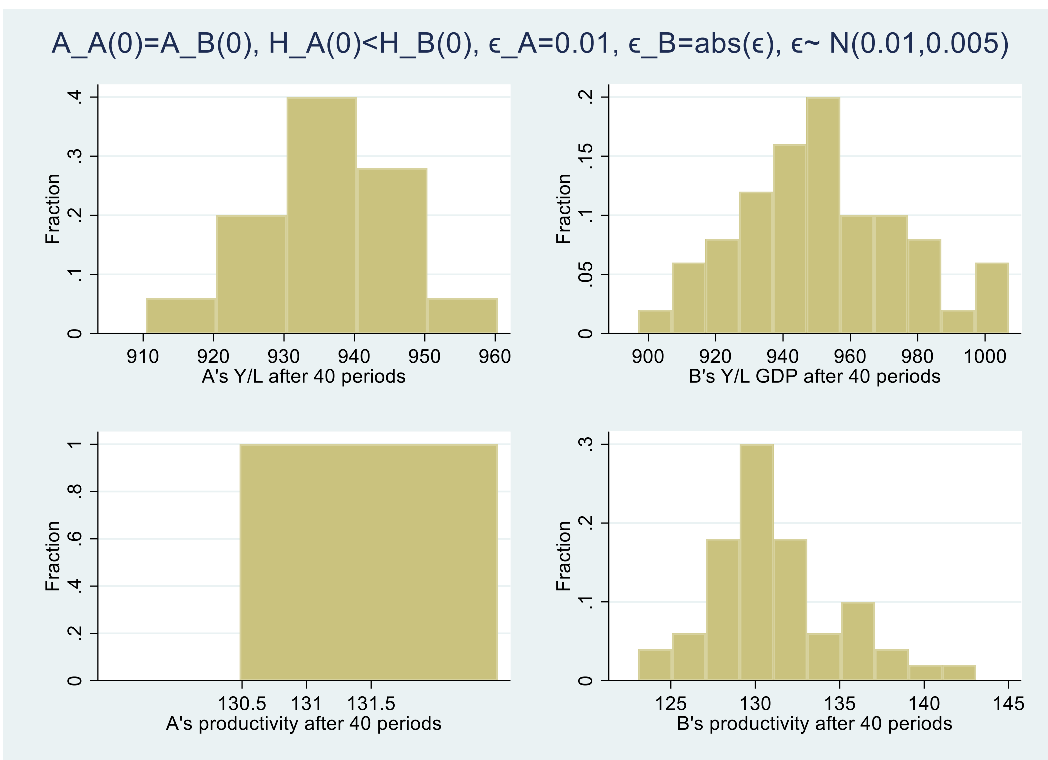
We can see from above chart that when both states begin with same values of $A(0)$ and $H_A(0) < H_B(0)$, when A receives a positive random shock and B receives a fixed positive shock to the productivity growth, both states have very close values of aggregate output as well as of per-capita output.

5. Here are the results when both states begin with same values of $A(0)$ and $H_A(0) < H_B(0)$, $\epsilon_A = 0.01, \epsilon_B = abs(\epsilon),\ \epsilon \sim N(0.01, 0.005)$

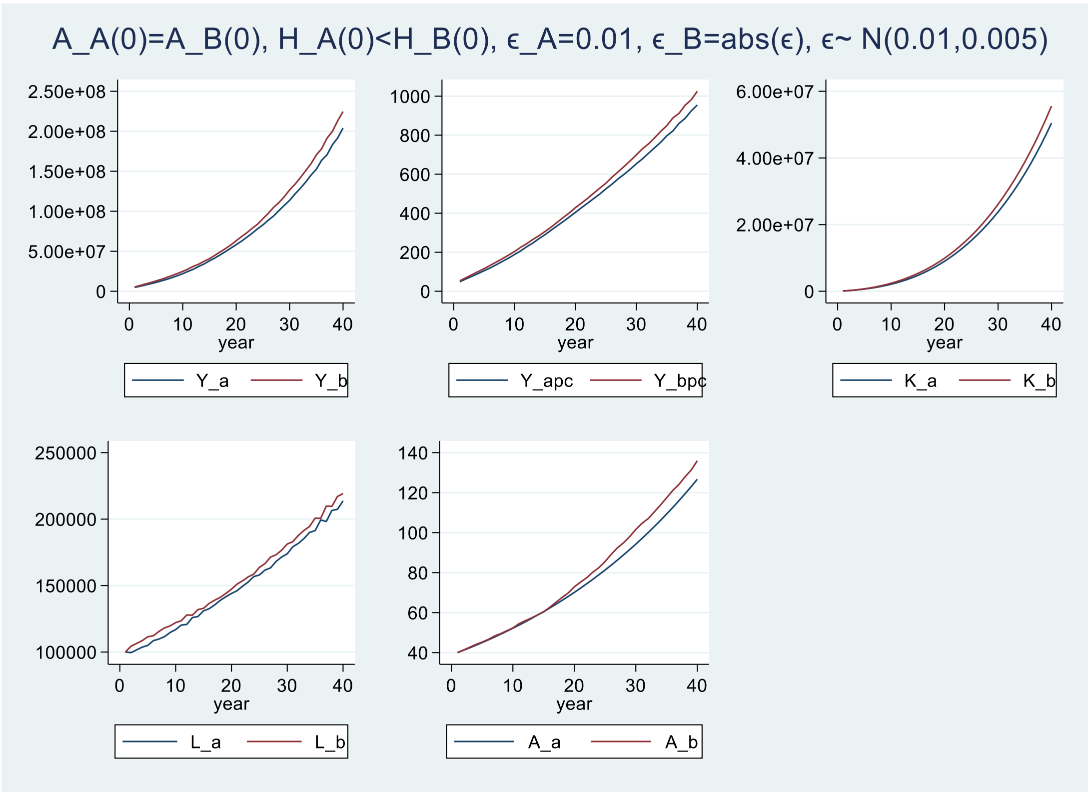
The following table shows the summary statistics of per-capita output (y), human capital (average years of schooling, h) and productivity(A) in the two states at the end of 40 periods:

Variable	Obs	Mean	Std. Dev.	Min	Max
y_a	50	935.208	9.938769	910.3712	954.4456
y_b	50	951.0328	24.58704	897.0156	999.2443
h_a	50	14.99995	4.41e-07	14.99995	14.99995
h_b	50	14.99997	6.42e-06	14.99995	14.99998
A_a	50	130.4815	0	130.4815	130.4815
A_b	50	131.2988	3.902345	123.0777	141.4827

The following histogram shows the distribution of per-capital output and or productivity in the two states at the end of 40 periods:



The following graphs show the evolution of economic indicators (aggregate output Y, per-capital output Y_pc, capital K, labor L, productivity A) for both the states over 40 years for one simulation:



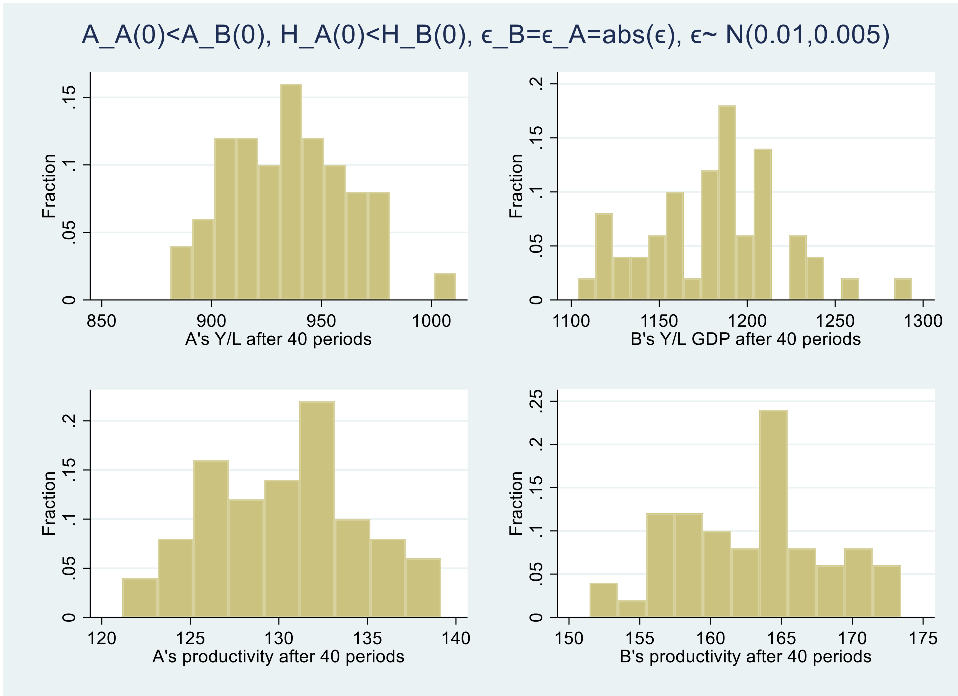
We can see from above chart that when both states begin with same values of $A(0)$ and $H_A(0) < H_B(0)$, when B receives a positive random shock and A receives a fixed positive shock to the productivity growth, there is a gradual divergence in aggregate output as well as of per-capita output between the two states. This also suggests that the initial advantage that B has in human capital gets slowly accentuated over time in this case.

6. Here are the results when $A_A(0) < A_B(0)$ $H_A(0) < H_B(0)$ $\epsilon_A = \epsilon_B = abs(\epsilon)$, $\epsilon \sim N(0.01, 0.005)$

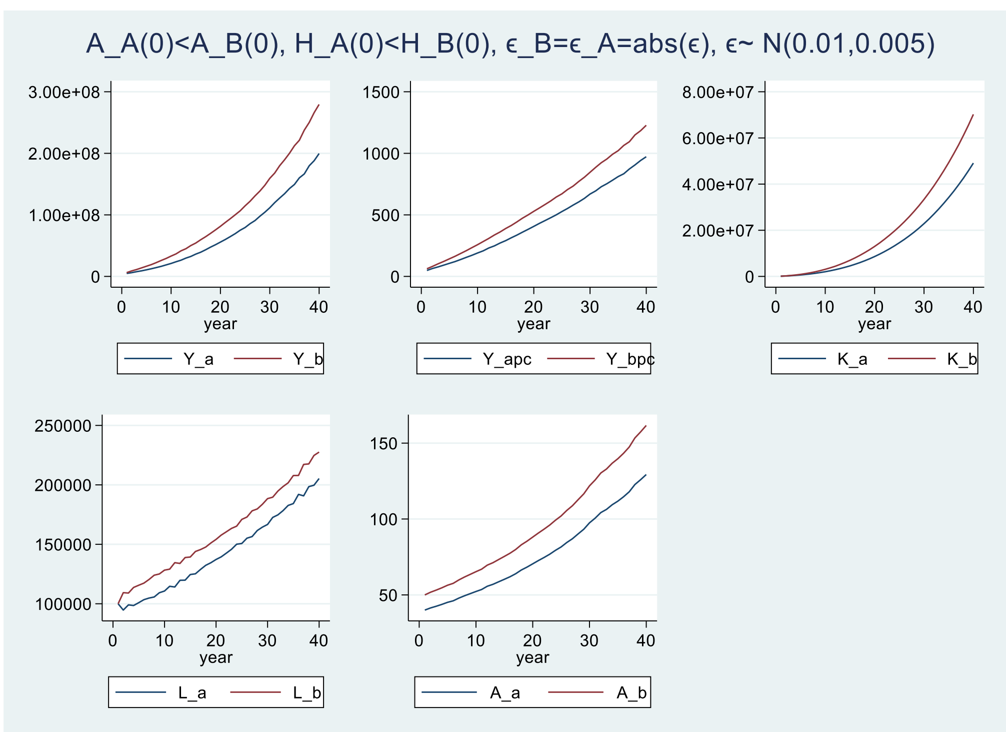
The following table shows the summary statistics of per-capita output (y), human capital (average years of schooling, h) and productivity(A) in the two states at the end of 40 periods:

Variable	Obs	Mean	Std. Dev.	Min	Max
y_a	50	934.8044	26.18385	881.126	1003.373
y_b	50	1181.417	38.36229	1103.706	1283.71
h_a	50	14.99995	.0000123	14.99992	14.99998
h_b	50	15	5.52e-07	15	15
A_a	50	130.3252	4.347293	121.1639	138.602
A_b	50	162.9065	5.434117	151.4548	173.2525

The following histogram shows the distribution of per-capital output in the two states at the end of 40 periods:



The following graphs show the evolution of economic indicators (aggregate output Y, per-capital output Y_pc, capital K, labor L, productivity A) for both the states over 40 years for one simulation:



We can see from above chart that when $A_A(0) < A_B(0)$ $H_A(0) < H_B(0)$, equal positive random shock to the productivity growth still lead to divergence in aggregate output as well as per-capita output.

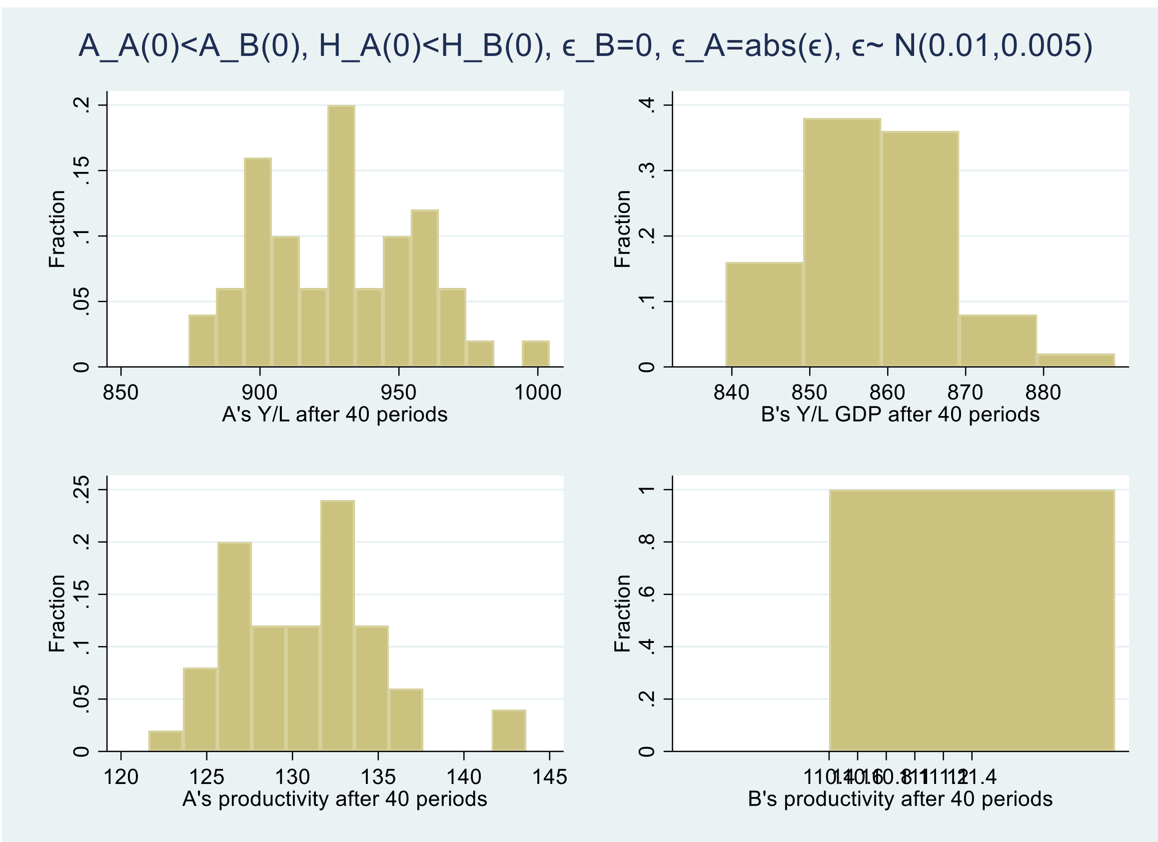
I also find that unequal but random positive shocks to productivity growth $[\epsilon_A \neq \epsilon_B, abs(\epsilon)$, $\epsilon \sim N(0.01, 0.005)]$ also lead to results very similar to above.

Moreover, when B receives a positive random shock and A receives a fixed positive shock to the productivity growth $[\epsilon_B = 0.01, \epsilon_A = abs(\epsilon),\ \epsilon \sim N(0.01, 0.005)]$, the results are again similar to above.

Also, when B receives a positive random shock and A receives a fixed positive shock to the productivity growth $[\epsilon_A = 0.01, \epsilon_B = abs(\epsilon),\ \epsilon \sim N(0.01, 0.005)]$, the results are again very similar to above.

7. Here are the results when $A_A(0) < A_B(0)$ $H_A(0) < H_B(0)$ $\epsilon_B = 0, \epsilon_A = abs(\epsilon)$, $\epsilon \sim N(0.01, 0.005)$

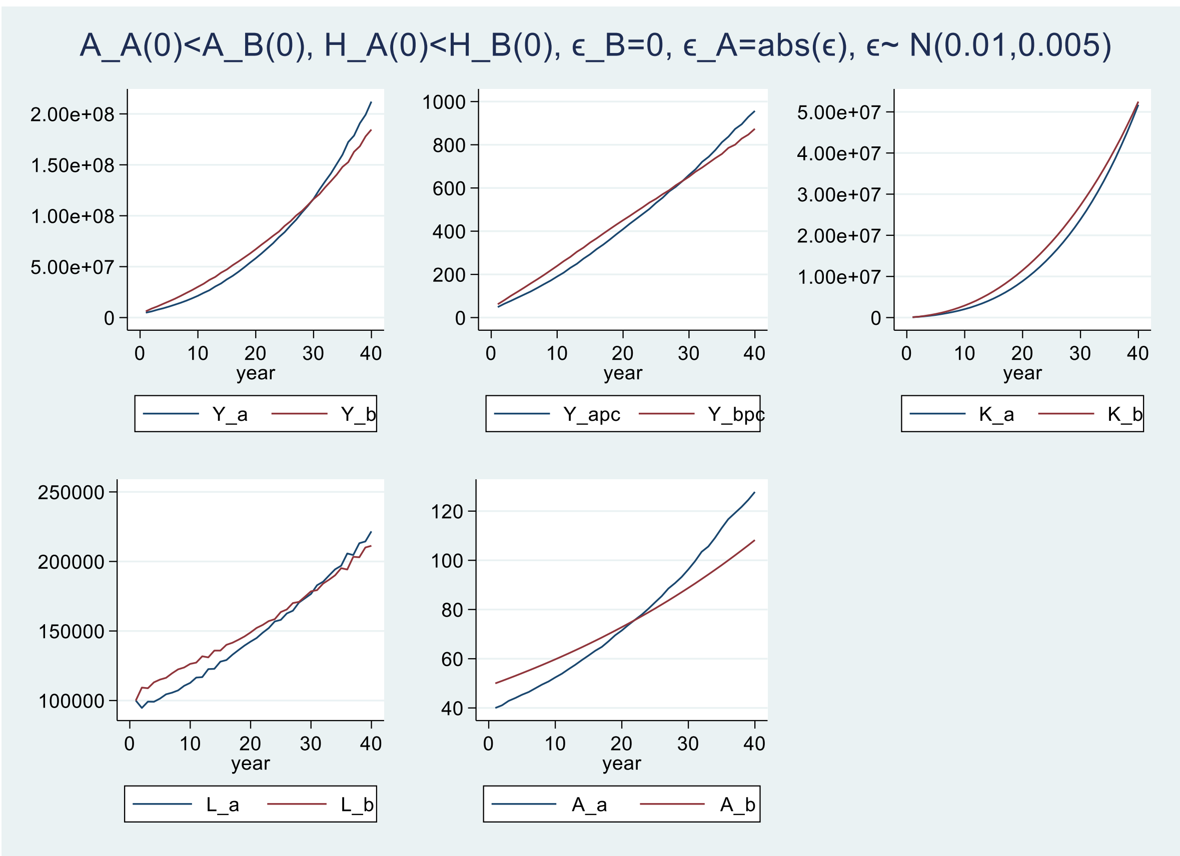
The following histogram shows the distribution of productivity and of per-capita output in the two states at the end of 40 periods:



The following table shows the summary statistics of per-capita output (y), human capital (average years of schooling, h) and productivity(A) in the two states at the end of 40 periods:

Variable	Obs	Mean	Std. Dev.	Min	Max
y_a	50	928.0102	28.39661	874.248	1000.282
y_b	50	857.8612	9.352235	839.1785	885.7938
h_a	50	14.99995	.0000123	14.99991	14.99997
h_b	50	14.99998	1.35e-07	14.99998	14.99998
A_a	50	130.7938	4.416259	121.6178	143.1063
A_b	50	110.402	0	110.402	110.402

The following graphs show the evolution of economic indicators (aggregate output Y, per-capital output Y_pc, capital K, labor L, productivity A) for both the states over 40 years for one simulation:



We can see from above chart that the aggregate output as well as per-capita output in A overtakes that in B over time when there is no shock to initially richer state B and a positive productivity shock to initially poorer state A. In this hypothetical scenario, the initially poorer state overtakes the initially richer state in economic indicators. Changing the variance of the shock to 0.001 also yield similar result.

Discussion and Conclusion:

In these cases, I have provided three combination of productivity growth shocks to the two states A and B:

a. $\epsilon_A = \epsilon_B = abs(\epsilon),\ \epsilon \sim N(0.01, 0.005)$
b. $\epsilon_A \neq \epsilon_B = abs(\epsilon),\ \epsilon \sim N(0.01, 0.005)$,
c. $\epsilon_B = 0.01, \epsilon_A = abs(\epsilon),\ \epsilon \sim N(0.01, 0.005)$
d. $\epsilon_A = 0.01, \epsilon_B = abs(\epsilon),\ \epsilon \sim N(0.01, 0.005)$
e. $\epsilon_B = 0,\ \epsilon_A = abs(\epsilon),\ \epsilon \sim N(0.01, 0.005)$

As we can see from the above simulations, despite the clear convergence in human capital (denoted by average years of schooling) between states, the economic indicators like aggregate output and per-capita output do not always follow similar paths in both the states. When the states start with same human capital and productivity (cases 1-2), they follow similar paths when they receive shocks characterized by a or b. When shocks are characterized by c or d, the states' aggregate and per-capita outputs start to slowly diverge over time with the state receiving the fixed shock slightly worse off.

When the states start with same productivity but B has higher initial human capital than A (cases 3-5), shocks characterized by a and b do not produce divergence even though B's aggregate and per-capita output is always greater than A. If the only difference between the two states is human capital and that caches up over time, both states very follow similar economic paths. When shocks are characterized by c, both states track each other closely. However, then the shocks are characterized by d., there is a gradual divergence between the two states. This also suggests that the initial advantage that B has in human capital gets slowly accentuated over time when it receives the random shock and A receives the fixed shock.

When states start off with different productivity and human capital, such that B is better off on both counts, then I observe stark divergence in cases of different shock combinations, namely a, b, c and. This suggests that the initial advantage of state B over A increases over time when there are very small differences in productivity growth between the two states. When shocks are characterized by e, i.e. when only A receives a productivity shock, then there is first a convergence and then the A overtakes B in terms of both per-capita and aggregate output. At the same time, the simulation results show that capital and labor also start to converge in this case.

This scenario is less plausible in reality. Although A's productivity can grow faster than B initially (suppose A leapfrogs some transition as its productivity catches up with B), it is unreasonable to think that this will continue to happens even after their productivity becomes equal.

At the same time, it is more conceivable that richer states receive higher productivity growth shocks than poorer states (in which case, the divergence in aggregate output and per-capita output will be even large, I do not show the simulation results here), The simulation results in cases 6 and 7 therefore suggest that positive productivity shocks that affect the two states similarly do little to attenuate the diverging economic trends in the two states. Hypothetically, a more dramatic shock to the initially poorer state might allow for that possibility.

The simulations in case 6 also show that after an initial divergence, the difference in populations of the two states becomes stable even though there is migration in each period. If we assume that productivity growth affects the whole economy in the same manner, then this simulation result is consistent with the economic trends we see among Indian states as shown in figure A1 and A2 where we see that initially poorer states have fallen further behind in terms of GDP per capita, number of factories.

Appendix:

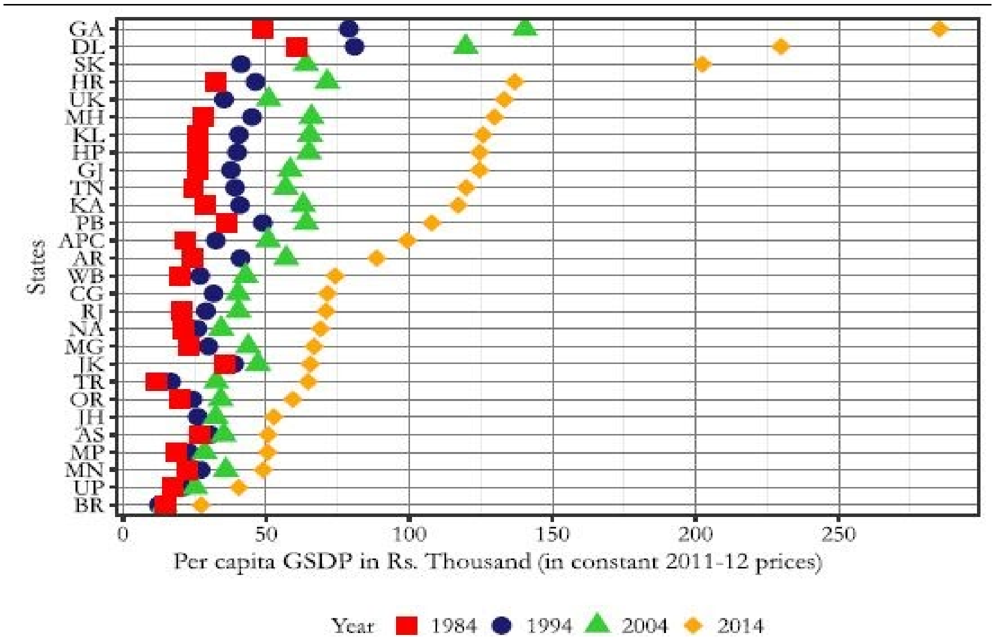


Figure A1: GDP per capita of Indian states (1984-2014)
[Source: Economic Survey of India, 2016-17]

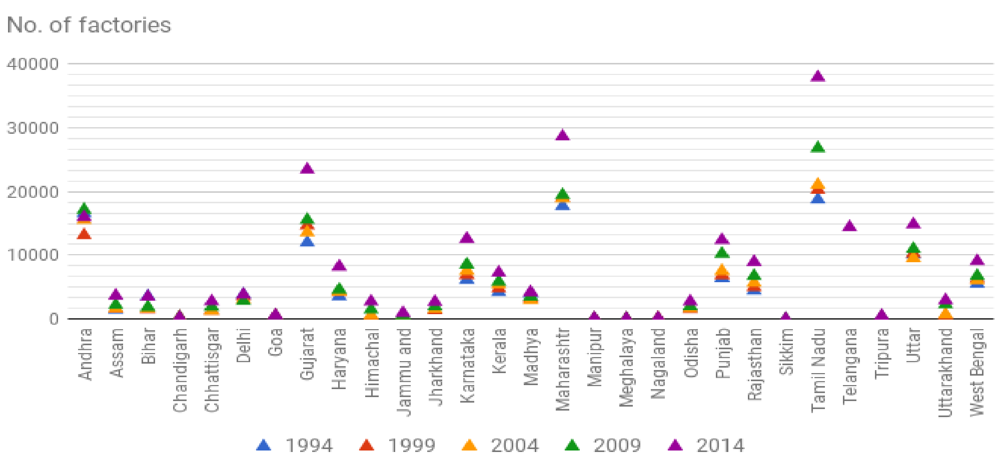


Figure A2: Number of factories in Indian states (1994-2014)
[Data source: Reserve bank of India]

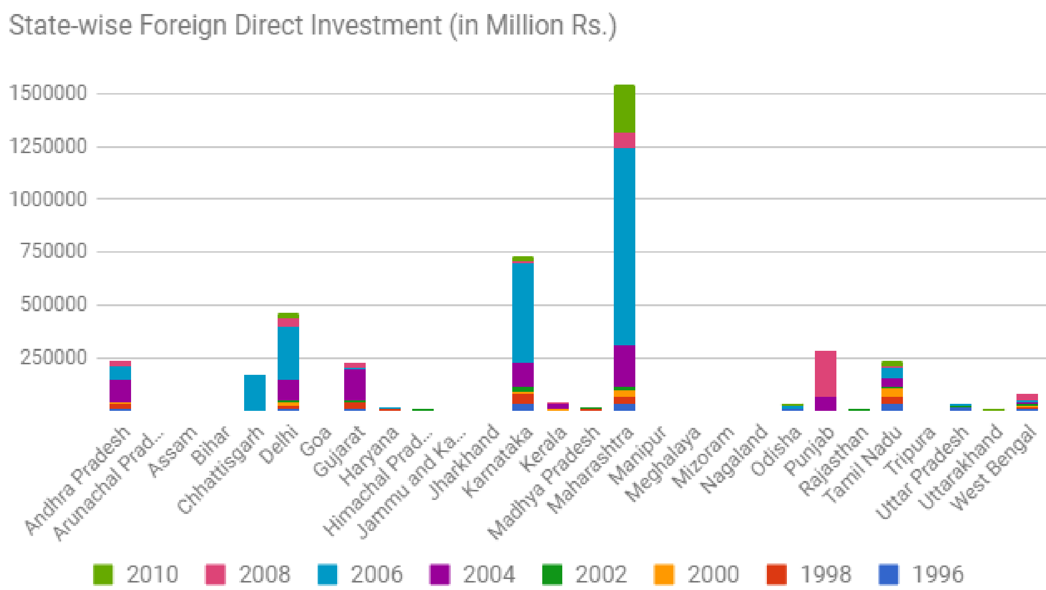


Figure A3: FDI in Indian States (1996-2010)
[Data source: Ministry of Commerce and Industry, Govt. of India]

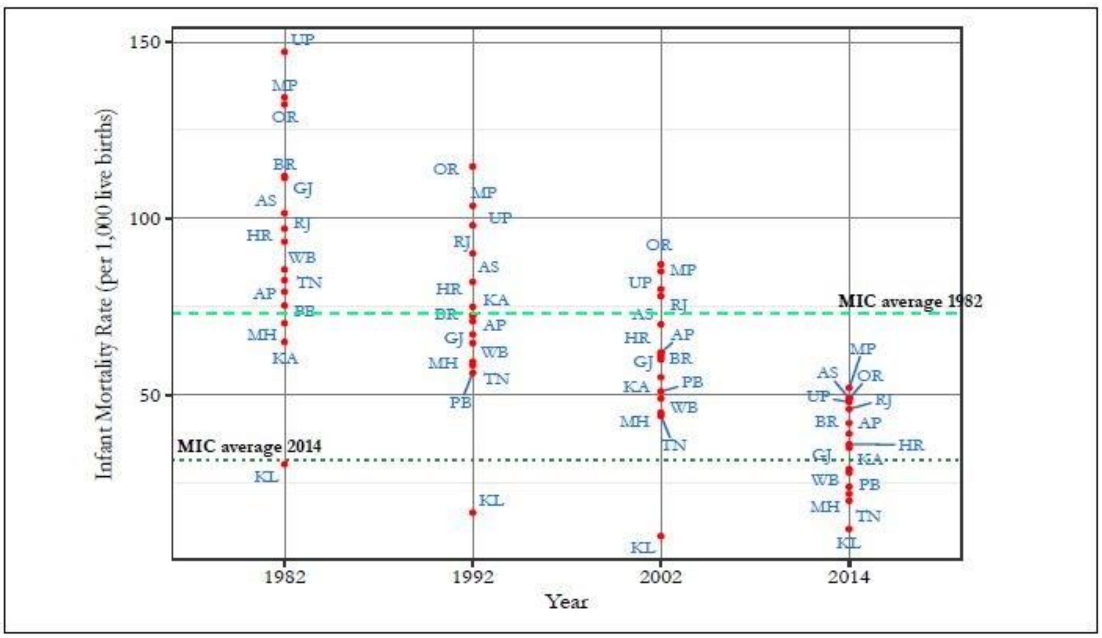


Figure A4: Infant mortality in Indian states (1982-2014)
[Source: Economic Survey of India, 2016-17]

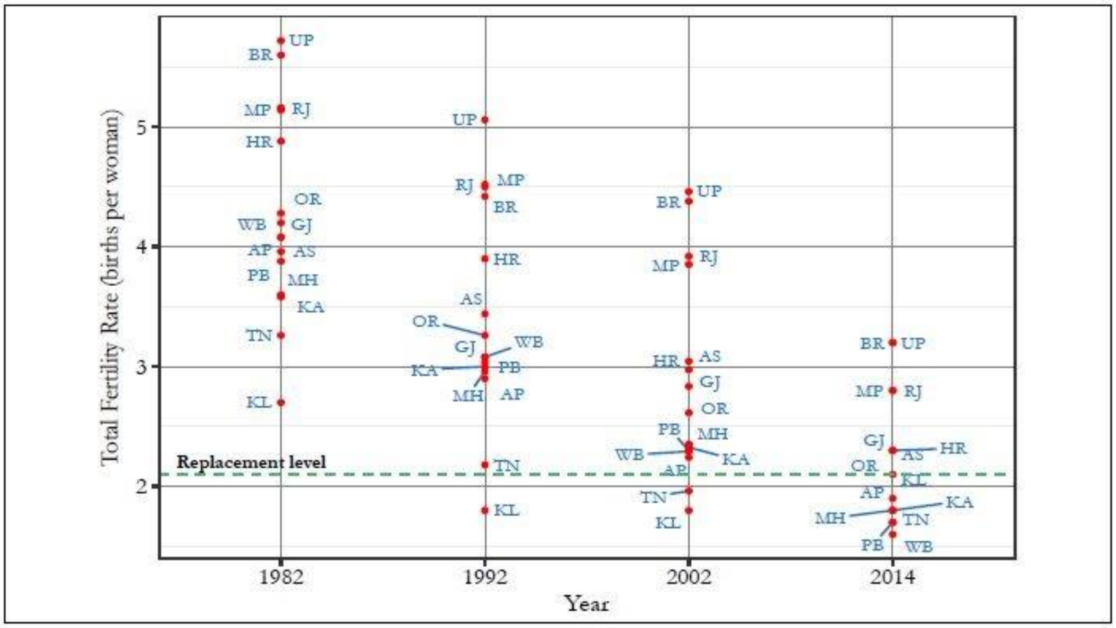


Figure A5: Total Fertility Rate in Indian States (1982-2014)
[Source: Economic Survey of India, 2016-17]

State	CMM 1991-2001 (%)	CMM 2001-2011 (%)	Net Migrants in 20-29 cohort, 1991-2001 (Thousands)	Net Migrants in 20-29 cohort, 2001-2011 (Thousands)
Delhi	46.1	15.6	887	466
Tamil Nadu	0.2	8.3	26	1,013
Goa	8.6	7.9	22	19
Kerala	1.3	7.0	395	900
Gujarat	0.8	3.2	69	343
Karnataka	-2.3	3.0	-224	348
Maharashtra	6.6	2.4	1,064	507
Andhra Pradesh	-1.1	-1.3	-148	-218
West Bengal	-0.2	-1.4	-30	-235
Punjab	-2.2	-1.5	-99	-82
Haryana	-0.9	-1.7	-34	-86
Assam	-4.2	-1.9	-209	-114
Odisha	-2.6	-3.7	-173	-290
Madhya Pradesh*	-1.2	-4.2	-166	-765
Rajasthan	-6.2	-6.2	-602	-791
Himachal Pradesh	-6.7	-6.8	-80	-90
Bihar*	-6.3	-11.1	-1,135	-2,695
Uttar Pradesh*	-9.9	-14.4	-2,955	-5,834
Total (Major Sending States)			-5,855	-11,200

Figure A6: Migration across Indian states
[Source: Economic Survey of India 2017]