Schumpeterian growth, health & spatial inequality

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1 Schumpeter: technology and health capital

Awhile ago, a colleague and I set out to examine the technological capability of Indonesia along with those of her neighbours, in a study comparing East Asia and South American countries [Tampubolon and Ramlogan, 2004]. We had to drop Indonesia from the comparison because simply there was next to nothing there. Recently, using similar data, the World Bank [Gill and Kharas, 2007] has come up with some “ideas for economic growth for East Asian Renaissance” where technological capability is prominent among them. In the intervening years between the two studies, there has not been much change in the position of Indonesia relative to her neighbours. And yet technological innovation looms even larger in guaranteeing our future prosperity and sustainability.

Peter Howitt and Philippe Aghion are at the forefront of theorists who point out to the importance of health capital for growth in prosperity and sustainability [Howitt, 2005]. In the pathway between health capital and prosperity lies technological innovation essential for this vision.

I shall present a simple model by borrowing closely from Howitt to point out how technology is important for growth and prosperity; and how health capital is in turn essential for technological development.

\[ Y = \psi F(K, AS(1 - \epsilon)), \]
\[ \dot{K} = \sigma Y - \delta K, \]
\[ \dot{L} = \eta L, \]
\[ \dot{S} = \lambda \epsilon L - \phi S, \]
\[ R = \rho Y, \]
\[ \dot{A} = v(A - A), \]
\[ \dot{\lambda} = \gamma A, \]

*Sujawoto has been an able research assistant for this work; to him I am grateful.
where the endogeneous variables are:

- \( Y \) Final output (GDP)
- \( K \) Capital stock
- \( S \) Stock of skills
- \( A \) Aggregate productivity
- \( L \) Labour force and population
- \( R \) Technology investment expenditure or research
- \( v \) Rate of innovation
- \( \mathcal{A} \) Global technology frontier

and the parameters, positive valued, are

- \( \psi \) productive efficiency
- \( \epsilon \) school attendance
- \( \sigma \) saving rate
- \( \delta \) depreciation rate
- \( \eta \) population growth rate
- \( \lambda \) learning efficiency
- \( \phi \) skill adjusted death rate
- \( \rho \) effective research intensity
- \( \gamma \) global frontier technology growth rate.

The first part consists of the four initial equations and is akin to Solow-Swan growth model. The remaining equations make up the part where the rate of technological growth depends on the country effectively investing a proportion of its output on technology research \( \rho \). Equation 6 highlights the fact that technological growth \( \dot{A} \) depends proportionately on the country’s rate of innovation \( v \) and the country’s distance to the global technology frontier. In this sense, Gerschenkron famously refers to an advantage of backwardness.

Meanwhile the global technology frontier continues to move at the rate \( \gamma \) which, together with equation 6, necessitate that the country maintaining a constant innovation rate \( v \) would have its productivity growing eventually at the global technology rate.

At the same time, the country must confront the disadvantage of backwardness, formulated in equation 8, which makes this innovation rate \( v \) inversely proportional to the global technology frontier. These advantage and disadvantage of backwardness are at the heart of the mechanics of growth which will drive a country like Indonesia along paths to growth and sustainability. What are the possible scenarios? There are convergence scenario where Indonesia will catch up and laggard scenario where Indonesia will lag far, or even farther, behind.

The panels in Figure 1 show the steady-state value of the country’s relative productivity \( a = \frac{A}{A^*} \) as a function of capital stock per effective worker \( k \equiv \frac{K}{AL} \). GDP per capita in converging country will grow at the same rate as the global technology frontier \( \gamma \) in the long run because its relative productivity has stabilised at a positive level.\(^1\) However, there is no guarantee that the

\(^1\)This is only possible if the numerator or the rate of domestic technology growth \( g \) is the
two curves $A$ and $K$ will intersect; a case is shown on the right panel. The country in this case will not grow as fast as the global frontier because even if its relative productivity falls to zero and thus bringing extreme advantage to backwardness, the disadvantage of backwardness will more than annihilate this. The growth rate then will be determined endogeneously and primarily by local conditions. The country’s GDP growth rate will fall forever relative to that of converging country.

What does this say about health and accumulation of domestic technology capability that will shift a country from the right to the left panel? Some channels are identified where population health contributes to growth.

**Life expectancy, $\phi$** Increases in life expectancy e.g. way beyond 40, directly increases the average skill level of the population through accumulated job experience. In Indonesia there has been a suggestion that demographic bonus can be expected in this respect.

**Learning capacity, $\lambda$** Children who are well nourished, vigorous and alert will gain more from the same hour of education than children who are stunted, wasted, or suffering from e.g. water-borne diseases.

**Creativity and coping skills, $\rho$** In a vivid and dramatic phrase, Schumpeter [1950, :18] delivers the heart of economic growth: creative destruction. Old technologies are destroyed and along with them old forms of works, uncompetitive companies, outdated industrial arrangements. Healthy and functionally literate workers with the help of government are better able to anticipate and to cope with the inevitable changes brought about by growth.

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same as the denominator $\gamma$.  

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Productive efficiency, \( \psi \)  Healthier workers are more productive due to increased vigour, strength, stamina, and so on. With the same set of physical capital and stock of knowledge, the country is more productive.

2 Spatial evidence and further analytics

Two spatial evidence begin to tell why Indonesia is still lagging behind and what could be the possible problem. First, I capture life expectancy, learning capacity, creativity and productive efficiency in one index and show its spatial distribution across the archipelago in the first map. The Human Poverty Index summarises life expectancy not exceeding 40, wasting and stunting, likelihood of water-borne diseases, and adult illiteracy rate. These measures addresses the channels identified in Howitt’s Schumpeterian growth model above. A scrutiny of this map shows that the outlying islands are home to many wasting and stunting children, high proportion of adults who barely start life if life indeed begins at forty, are exposed to high incidence of water-borne diseases, and are functionally illiterate. The further the kabupaten is from the centre the further it lags behind in health capital; in turn, the lower the potential for growth and prosperity through technology innovation.

In the next map, the spatial distribution of primary health care through Puskesmas starkly mirrors the spatial distribution of the Human Poverty Index. This Puskesmas map is yet to incorporate the quality of delivery; little doubt that the distressing conclusion will be even more reinforced.

This exercise in mapping composite health outcomes and health provision is only one step in our understanding of how spatial distribution brings out health inequalities in Indonesia. We are exploring, both in Manchester and Yogyakarta, different ways of getting the answers to the persistent spatial inequalities in health observed here. I digress briefly by theorising the role of interactions in space and how they can shape health outcome. Then I present results on the analysis of health visits accounting for communities in different geographies.

3 Statistical physics of social interactions in space

This section is from Tampubolon [2009] which builds on an influential theory of health capital due to Grossman [1972]. Works on social inequalities of health by sociologists, epidemiologists and public health professionals can be bridged with works on health capital by health economists. I build this bridge by recognising the importance of community factors in theories used by both groups of scholars. In building this bridge, the Grossman theory of health capital is extended to include community factors. The factors include community deprivation and community social capital. I show that sociologists, epidemiologists, public health professionals and economists can fruitfully use community deprivation and social capital in deepening their understanding of health inequalities.

The extended model can be presented as in Figure 3 where it is depicted that
Figure 2: Spatial distribution of Human Poverty Index (top) and of Puskesmas (bottom) by kabupaten and kotamadya in Indonesia, 2007. Source: BKIA net
processes determining health are not circumscribed entirely within the individual but are also affected by community social capital and deprivation. Adopting the notation of Case and Deaton [2005], assume there is an instantaneous felicity function $\nu(c_t, H_t)$ where $t$ is age, $c_t$ is consumption, and $H_t$ is the stock of health. Health is produced according to

$$H_{t+1} = \theta m_t + (1 - \delta_t)H_t$$

(9)

where $m_t$ is the decisions and behaviours for maintenance of health (including medical care bought and health promoting activities undertaken), $\theta$ is the efficiency or conversion factor which is affected by education (and other socio-economic status) and $\delta$ is the rate of health deterioration at $t$. People maximise a life cycle welfare function

$$U = \sum_0^T (1 + \rho)^t \nu(c_t, H_t)$$

(10)

where $\rho$ expresses time preference, and $T$ is the length of life. The welfare is optimized subject to full wealth constraint incorporating both wealth and time limits:

$$\sum_0^T \frac{c_t}{(1 + r)^t} + \sum_0^T \frac{p_m m_t}{(1 + r)^t} = W_0 + \sum_0^T \frac{y_t(H_t)}{(1 + r)^t}$$

(11)

where $r$ is the market rate of interest, $p_m$ is the price of medical care and other health behaviours, $W_0$ is initial assets, and $y_t(H_t)$ is earning, a function of health.
Optimising the welfare function subject to the constraint as the health stock changes gives insights into issues like the role of education and inequalities in health. They have often been tested empirically by assuming functional forms for the elements of the theory. Wagstaff, Dustman and Windmeijer provide some example assumptions which enable empirical estimation. Thus empirical equations for health production function and for health maintenance are:

\[ H = H(M, W, X, \mu_h) \] (12)

and

\[ M = M(W, Y, \mu_m) \] (13)

where W is wealth, X and Y include age, education and exogeneous variables. The last equation contains exclusion restriction and the \( \mu \)'s are residuals.

This is emphatically a recursive or triangular system as \( M \), in turn, enters the health production function. This system is also known as multiprocess system. Recently, Balia and Jones [2008] estimated a similar recursive system of health maintenance behaviour, health outcomes and mortality. Their recursive structure is intuitively and formally in that order: maintenance, health, mortality. They recognise the correlated structure of the system and estimate the system’s parameters including residual correlations using simulated maximum likelihood.

I propose an extension broadening the model to include community factors. This extension acts as a bridge between the economics of health and epidemiology and public health. In the Grossman model, demand for the maintenance of health, \( M \), is narrowly and individually defined. However, if we construe maintenance to include general maintenance of health and avoidance of risks which affect health then we are in a position to include community factors. The benefits of this extension include increased scope of explanation and intervention.


Typically, a non-market interaction model of felicity for individual \( i \), \( \nu^i(a_i, Z_i, \theta) \), has the elements of individual action, \( a_i \), function of moments of community (or reference group) actions (usually negative), \( Z_i \), and a shock to the felicity function, \( \theta \), as a result of taking the action. The roles of the first and last elements are obvious; the second element captures sanction from deviating from the norm or encouragement from reinforcing the norm.

Brock and Durlauf (1995) for instance use the following global non-market interaction model (see also Aoki [1995]).

\[ V = m_i + J(1 - Z_i)^2 + \epsilon(1 - m_i) \] (14)
where \( m \) is the maintenance of health action, \( J \) is the penalty intensified by deviation from community average or norm of action \( Z_i \) and \( \epsilon \) is a taste shock. Essentially the second term is a function of community moment reflecting the fact of community norm (statistically, function of community moments) should have an effect on individual action.

Obesity can be used as an illustration. We are told that food portions in America have increased in the last three decades [Nielsen and Popkin, 2003]. Finishing the increasingly hearty plate clean, while dining out with friends is an instance of non-market interaction. What one orders to begin with (“Just a salad for me.”) Or “The full monty, please”) and what one finishes, \( a_i \), is not unrelated to what everyone else around the table order or finish, \( Z_i \). This scene extends, with attenuation, over to the community and over time. For instance Christakis and Fowler [2007] suggest that in Framingham, greater Boston, network of friends act as conduit of acceptable norm of body weight. Operating over 30 years, this network of friends led to increase in obesity through this non-market interaction. The authors were careful to account for individual socio-demographic factors and other place factors. Tampubolon et al. [2009] find, in a national sample in Wales, that friendly neighbours and communities also lead to increase in obesity. We carefully separate out the effect of individual sociodemographic and geographic factors in a multilevel multiprocess model which simultaneously explain consumption, physical exercise and obesity.

Glaeser and Schéinkman show that, for estimable hence desirable discrete equilibria, it is sufficient that the second derivative of felicity with respect to one’s own action is greater than partial cross-derivative between one’s own action and the community’s action. Or \( \left| \frac{d^2 \nu_i}{da_i^2} / \frac{d^2 \nu_i}{da_i dZ_i} \right| > 1 \). This they term moderate social influence condition (:340, 352). It means the effect of one’s action on one’s self must be greater than the induced effect through non-market interaction on one’s neighbours.

Again, using obesity as an illustration: jogging by an individual should improve the individual’s body mass composition. This improvement should be greater than induced improvement in the body mass composition of the neighbours. Some neighbours were inspired to take up jogging while others were not. Or using smoking (a health risk) as an illustration: smoking by an individual harms the individual’s health. This deleterious effect should be more severe than induced harm in the health of the neighbours through either passive smoking or through non-market or social norm effect. Excessive drinking and social drinking work similarly. In these cases, the moderate social influence condition is satisfied. One case where the condition is perhaps not satisfied is unprotected sex; \( \left| \frac{d^2 \nu_i}{da_i^2} / \frac{d^2 \nu_i}{da_i dA_i} \right| \not> 1 \). Fortunately, I am not applying this extended theory to this case.

Because non-market interaction can produce discrete multiple equilibria in health behaviours, it is not surprising to observe different communities in greater Boston (Framingham versus Backbay) to possess different obesity rates. The discreteness, hence the possibility of estimating them, is guaranteed by the moderate social influence condition.
Notably, this moderate social influence condition is consistent with the basic tenet of epidemiology or public health research [Rose, 1992]. It is well known that community effect of health behaviour (its regression coefficient in ecologic regression where the unit of analysis is communities, not individual) is usually smaller, often an order of magnitude smaller, than the individual effect or coefficient (in individual regression or in multilevel regression). The threshold for effect magnitude in a public health setting is typically lower than that in a clinical setting. An intervention bringing two percent decrease in the average population body mass index is already considered important though an order of magnitude larger effect is perhaps needed for a clinically obese individual. This lower threshold for population or higher sensitivity is accepted because one borne in mind that the ultimate effect is for the whole population and not confined to a single individual.

In parallel to theoretically recognising the importance of non-market interaction, it is practically acknowledged that built and social features of community can induce benefits as well as pose risks of health, e.g. Srinivasan et al. [2003]. The recursive system (equations 12 & 13) incorporating insights from non-market interaction is easily modified by including community effects such as community deprivation and community social capital, $Z$, in both health production function and maintenance demand:

$$H = H(M, Z, W, X, \mu_{hij}, \epsilon_j)$$ (15)

and

$$M = M(Z, W, Y, \mu_{mij}, \epsilon_j)$$ (16)

where $\epsilon$’s are the community residual. The individual residuals ($\mu_h$ and $\mu_m$) now gain individual $i$ and community $j$ indices.

4 Result of random effect Poisson model on health visits

The massive damage to people’s well being as a result of the Asian crisis of 1998 should be evident on their health. Indeed so: prior to the crisis (1993) 15% of the people self-report themselves to be very well; this drops to 9% and 6% post-crisis (1997 and 2000, respectively). Another evidence is provided by the number of activities of daily living they are able to carry out where higher number means healthier. Prior to the crisis only one in ten is slightly ill i.e. can only do seven or less activities. It rises to 17% and stays there after the crisis. This prima facie evidence of the deleterious effects of crisis on well being is further explored in a multivariate setting. The result is given in Table 1 where gender, age, age$^2$, education, employment, residence, consumption per capita are included though not reported.
Sample | Original | Plus new member
---|---|---
Post-crisis | 0.882 | 0.813
       | (-4.35) | (-9.17)
Community cohesion | 0.987 | 0.985
       | (-2.00) | (-2.99)
Number of volunteers | 1.004 | 1.006
       | (2.34) | (4.25)
$\sigma^2_j$ | 1.304 | 1.528
N | 27 470 | 51 879

Two points are highlighted here: the overall positive effect of community social capital and the remaining significant spatial inequalities in health care visits. Both community cohesion and number of volunteers are significantly related to visits to health care facilities: one improving health while the other reducing health. The overall effect is still positive. Even the negative effect could be interpreted as a provision effect. Communities with more social capital in the form of volunteers may have succeeded in encouraging residents to visit health care facilities when needed instead of delaying the visit.

Even after accounting for the community effects, however, there remains significant spatial inequality across the different communities, $\sigma^2$. This is consistent with the maps shown earlier.

5 Conclusion

Spatial inequality risks becoming the elephant in the room. A huge problem nobody wants to recognise ironically because of its apparent size. We risks giving up on serious attempt before even trying to grasp with the problem of spatial inequalities in health. The design decision of the IFLS is a telltale sign of the elephant. Only 13 provinces, equivalent to 83 percent of the Indonesian population, are covered in the survey. This of course is cost effective. But here is another way to think about it. If the American funded project failed to grasp with the problem of the cost of the national project, what hope is there for those outlying islands to be seen and heard and ultimately served and cured? The spatial problem is indeed challenging.

The modern history of Indonesia is of course an antidote to this paralysing problem. The fact that some access is available is already a basis to build upon. The place has not fallen apart; it take some effort to keep it together. Taking an honest and cold look at spatial inequality across the archipelago is a good start to prevent geography becoming a catastrophe. A geography where the spatial inequality is so severe as to question the identity of the country.

References


