Game Theoretic Models for Development Economics Applications

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Contents

Part 1

Game Theory Overview

Game theory was discovered as a framework for studying strategic interaction between rational actors. Pioneering work includes Augustin Cournot's *Mathematical Principles of the Theory of Wealth* (1838) and Francis Edgeworth's *Mathematical Psychics* (1881), which modelled the actions of firms in oligopolistic markets and were complemented by the work of Joseph Bertrand (1883) and Heinrich Stackelberg (1934) in this space. More general utility and solution frameworks came in the renowned *Theory of Games and Economic Behavior* (1944) by John von Neumann and Oskar Morgenstern, and their work was soon thereafter refined by John Nash (1950). Overall, fifteen game theorists have won the Nobel Prize in economics for their work, and game theory has long been a central component in the study of market strategy, political policy, defence, natural resource usage, pollution, international trade, and much more. All of these things contribute to economic growth and production. Still, in comparison to these other fields of economics, surprisingly little work directly relates game theory to development at a macroeconomic level. Nevertheless, games often have extensive applications and can be applied to scenarios that players face in a variety of contexts. This paper seeks to establish some of those connections. This exploration may be useful in better understanding current problems in development economics and provide rationales for why agents act the way they do. Part 2 will present games in application contexts and discuss equilibrium outcomes of these games, then analyse the significance of such outcomes.

Development Economics Overview

Development is a branch of economics that analyses the factors contributing to a nation's prosperity (or lack thereof). An ever-present motivation to reduce variation in the standard of life internationally results in an emphasis on underdeveloped and emerging nations and is often backed by organisations like the International Monetary Fund and the World Bank. The development of a country is evaluated on seven factors: poverty, inequality, education, health, nutrition, access to services, and shelter. The root of these factors, and their cross-country differences, can be attributed to four sweeping reasons: geography, institutions, culture, and luck. The last of these is important, but difficult to model; it is always accepted and rarely analysed. Within the three prior reasons, efforts have been made to distil cross-country income differences into factors vs efficiency: essentially, Income = F(Factors, Efficiency). Caselli's (2004) development accounting models point to efficiency as the foremost determinant of cross-country income variation, supporting prior assumptions. This suggests that work should be concentrated on improving production at current levels of capital rather than efforting to obtain more capital. Research in development economics has more recently produced work in health (including mental), households/marriage/family planning, gender, climate/pollution, and elections along with established fields like education and early childhood development, trade, labour, infrastructure, and conflict/crime/corruption.

The Integration

This paper will explore ways in which game theory can be utilised as a helpful tool in understanding modern development problems, through the use of specific applications, and hopefully provide insight into the complex problems that agents (whether individuals, industries, or governments) face in these types of scenarios. In keeping with the widely accepted reasons for cross-country differences, games will be modelled in three sections:

- *Geography*: Location models (Hotelling's model, Salop's Model, etc.) show optimal settlement strategies, applicable to both competing civilizations and intra-country settings, and produce interesting real-world phenomena.
- *Institutions*: A broad category of legislation, infrastructure, networks, and more that is difficult to distinguish from the other two categories; this is where the most related work exists. Through the narrowed lens of education, I model development traps in games and explore how officials can help escape these traps.
- *Culture*: Intruding cultures, specifically in a religious context, are modelled using evolutionary games and long-term stability is examined.

Each section will assess the relevance of the games and complex, underlying circumstances for agents will also be addressed. On a practical note, countless confounding variables can separate theory from reality, although this has rarely stopped economists before. And while not all variables can be addressed, I strive to find case examples with clear patterns that most purely resemble the games.

Part 2

The following section will attach game types to the three fundamental causes of economic development and growth: geography, institutions, and culture. Supplementary case studies will provide historical context to games, and modifications to the structure of the game will demonstrate the complexity of situations and circumstances for players.

I: Geography

Territoriality Disputes and Clustering

> *"What makes a nation in the beginning is a good piece of geography."*
> *- Robert Frost*

Geography plays an obviously important role in the development of a state. It influences trade, industry, and defence, crucial components of prosperity. Acemoglu (2009) asserts, "The geography hypothesis is, first and foremost, about the fact that not all areas of the world are created equal. 'Nature', that is, the physical, ecological and geographical environment of nations, plays a major role in their economic experiences." The means by which aspects of geography impact development are still controversial, and influence corresponding approaches to solving development disparities. Climate, soil fertility, landscape characteristics, and ecological profiles have been hypothesised to affect human attitudes and effort, available technology, or susceptibility to disease in any number of ways. Although not created equal, and certainly complicated, areas of the world provide options to inhabitants and, given some degree of autonomy either within a social contract or predating one, agents of the world will try to maximise their condition.

The incentive to deviate is a foundational element of economics. At its core, it is a representation of the 'pursuit of happiness' which economists try to model. Individuals strive to maximise utility, firms maximise profit, and countries maximise GDP; deviations are movements closer to optimal states. The incentive to deviate is the motor for demand and supply, seen throughout the study of economics in things like franchise locations and real-estate prices. In game theory, this incentive to deviate brings players to Nash equilibriums, if they exist.

Concentrations of people often represent areas which, for whatever reason, are desirable to move towards.[1] The population of a city is arguably no more than a statistic regarding the number of agents seeking to maximise their payoffs or utility in that location. Concentrations represent strong desirability; they are often located along major bodies of water, areas with high natural resources and good climates, areas of education and innovation, etc. Finding game theory optimal domains can be deduced from maps and data, but perhaps they can also be modelled and understood theoretically.

Consider an area of land which is a straight line, and across which there is a uniform distribution of resources (or general desirability), an adaptation of Hotelling's Model.[2] Nation *A* must settle along the line in an effort to maximise resource proximity. Where will they settle? Indeed, the only place for sensible settlement is in the middle of the line. Moving closer towards either pole would be a disservice to its members, who prefer to minimise travel.

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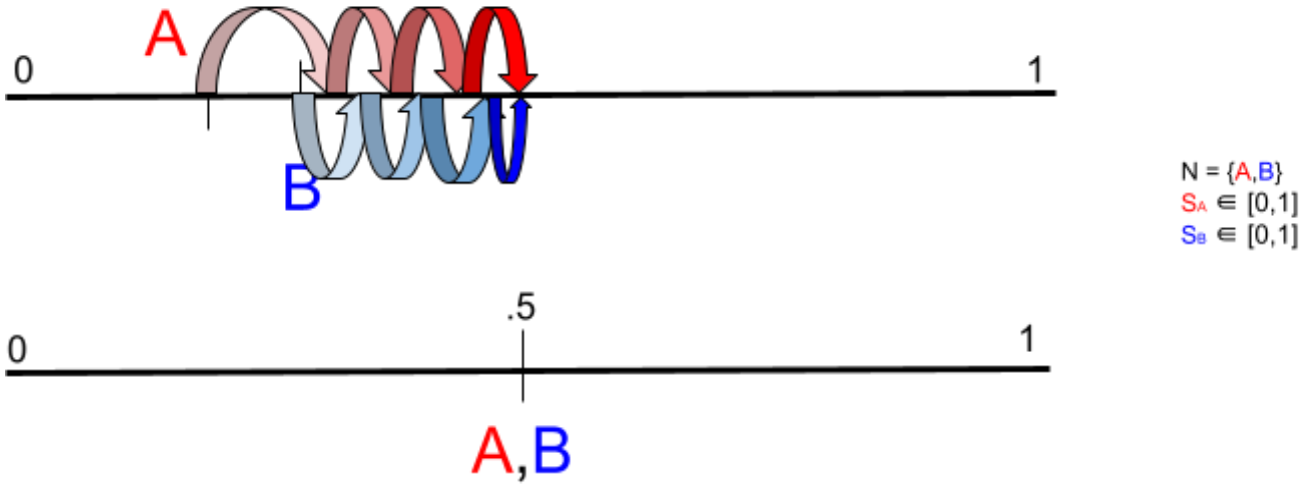
[1] And the reason may be just the fact that there is a concentration of people there, in a consequent snowball effect.

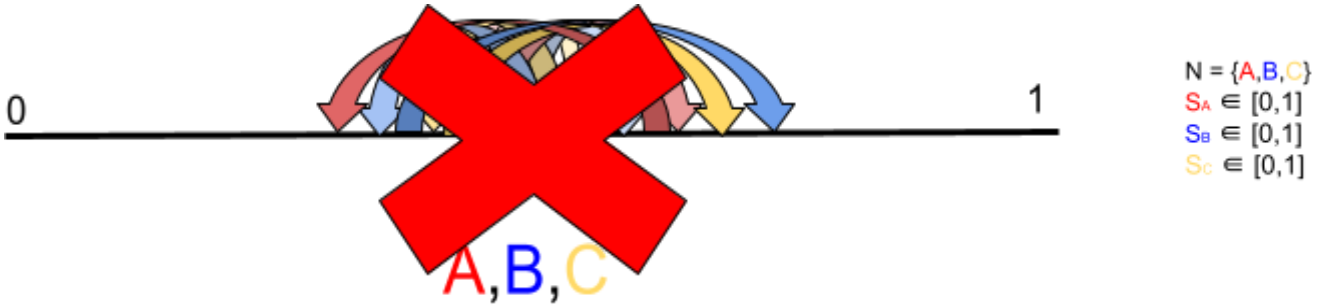
[2] Applied to strategy in political science, pricing, and other scenarios, the most common representation of Hotelling's game resembles the following: *Consider a street on which two vendors, who sell an identical product at an identical price, must choose the location for their shop, and across which customers are uniformly distributed. If customers prefer to minimise travel, where will the vendors choose to set up shop?*

Now consider the entry of another nation, *B,* so that the two nations must try to maximise proximal resources relative to the other. Where will they settle now? There is only one Nash outcome in this game, which is founded on the following two premises:

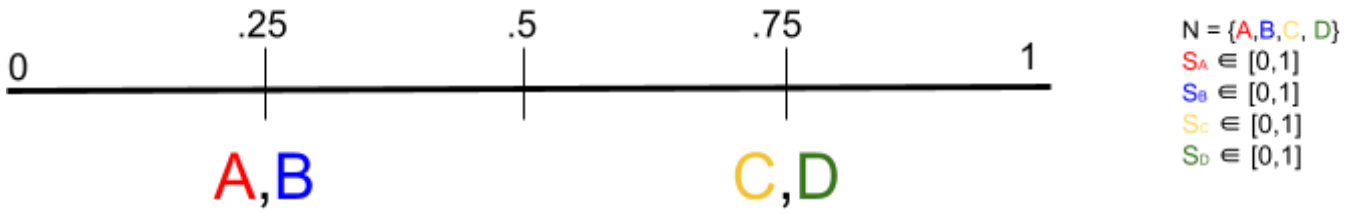
1. Both A and B will be at the same point: Since both try to maximise the amount of resources closest to them, relative to the other, they will move ever closer to each other to cut into their opponent's settlement and add to their own.
2. Both A and B will be in the middle: Maximising proximal resources also results in both settling in the middle, otherwise, one nation would have an incentive to be marginally closer to the middle than the other in their pursuit of proximal resources.



Both countries settle in the centre of the line, and from there neither has an incentive to deviate. Does a Nash equilibrium exist for three nations, *A, B,* and *C*? The answer is *no*: In any configuration, players will have an incentive to deviate. Their pursuit to gain more from the other will be endless, with no point of settlement.

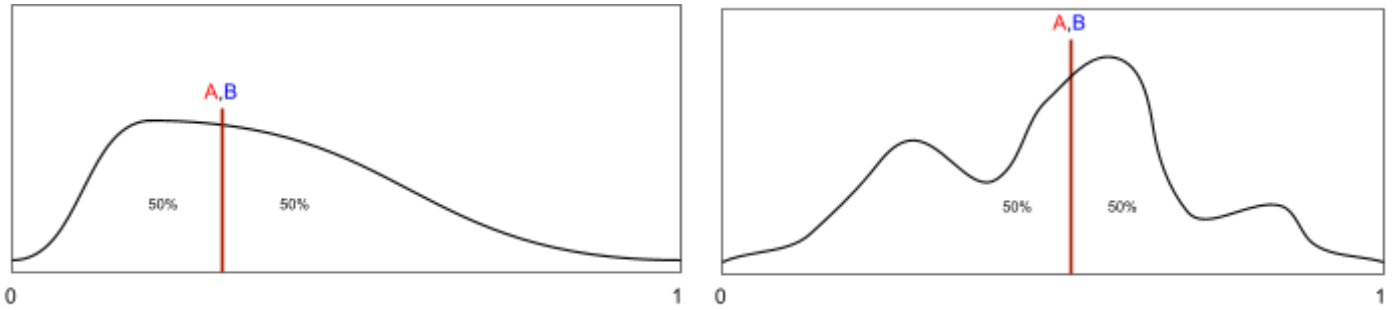


Now, introducing a fourth player *does* provide the possibility for Nash again. The configuration of this equilibrium, shown below, is two nations at ¼ of the distance along the line, and two nations at ¾ of the distance along this line. From this point, no nation can do better than its current share of resources.



In fact, (theorem:) all games with an even number of players have a pure strategy Nash equilibrium where two players share a location across a line's length at every odd numerator where the denominator is the total number of players. This sort of clustering is an interesting result of Hotelling's game. Still, note that in our application of nation settlement, any deviation at all would require upending a civilization and moving it to a new location. And there's no telling how long the process of finding this Nash (where no one has any more incentive to move) may take in practice. These sorts of barriers are obviously not addressed in this simple game, but the fact persists that the introduction of players can disturb current gameplay.

Now, uniform distribution of resources/desirability along the line is a strong, and often unrealistic, assumption. Distributions may have more organic shapes like the ones shown below.



And while we can still find the median point and accordingly the Nash equilibrium in games of two players (as shown), adding in more players is likely to disturb the proximity principle in non-uniform distributions.[3] Nevertheless, it's intuitive that the bulk of players will congregate in areas of high resource concentration. If, for instance, we were looking at a population density map, we would expect the highest population densities in the areas where the resource concentrations are highest. Even if no 'final state' Nash equilibrium exists, the pursuit of greater utility will still concentrate the majority of people in the areas where there are the majority of resources, naturally. The same concept is applicable intra-country as well, where players are households or businesses.

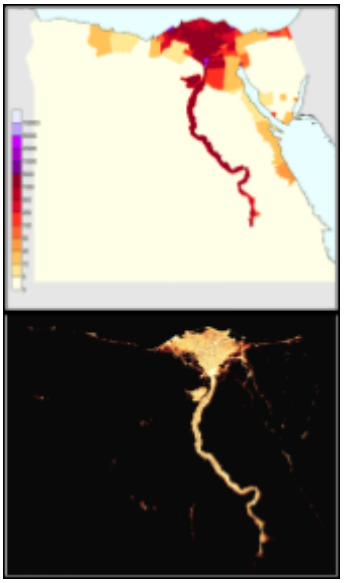
* * *

Case Study: Egypt

Egypt's geography is defined by an 800km river stretching from Aswan (southern end) to Cairo (northern end), and its 2200 km^2 delta—some of the world's most fertile land amidst the Sahara desert. The cultivable land makes up under 5% of the country's surface area and supports nearly its entire population. The Nile River is the nucleus for irrigation, fishing, and transportation in the country and has consequently formed the basis for residence and industry. All of this produces one of the most interesting maps for perusal. Non-coincidentally, Egypt, as well as the Fertile Crescent (comprising the

[3] That is, Nash equilibria are unlikely to exist in organic or non-uniform distributions since a deviation from any "cluster" does not provide the same level of proximal resources. Games will most likely draw players to move towards areas of higher resource concentration.

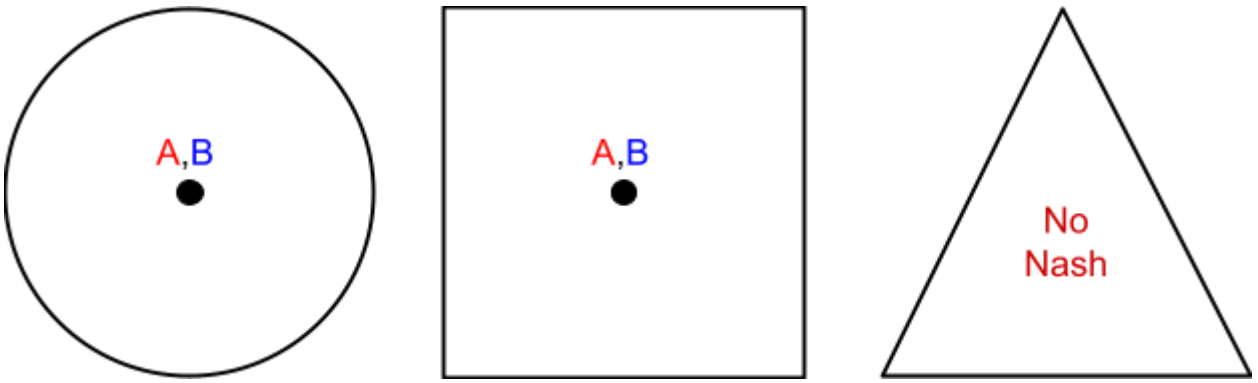
Mesopotamian basin and the Jordan River basin) and the oil-rich Persian Gulf region, have been sights of frequent conflict since the origin of civilization. Constant instability predates the latest news headline from this region by over 5000 years. Pockets of immense food production capabilities, resource wealth, valuable trade routes, and a coveted location between three continents pose attractive incentives for rational and informed players.



Although the Nile is perhaps the most apparent representation of clustering, throughout the world exist examples of strategically advantageous geography. The Mississippi River, for instance, generates over one-billion USD daily in earnings, serving as the lifeblood of adjacent states' economies.[4] In recent years, natural capital accounting has played an increasingly important role in evaluating economic systems not just by GDP, but by the natural factors underlying GDP, stressing the importance of monitoring and valuing natural assets. Several G20 countries are currently developing environmental accounts, either for integration with national accounts or to create environmentally-adjusted macroeconomic indicators like Green GDP. It is important that this progress reaches underdeveloped countries, too, where sustainable development is paramount.

* * *

Another often unrealistic assumption is likely the line itself—not every country is defined by exceptionally fertile river banks amidst the harshest desert in the world. When analysing a nation or a territory composed of nations it's often more appropriate to use shapes with area. Below are equilibria in two-player games, where there is a uniform distribution across the shapes.



Notice that (theorem:) a two-player Nash exists at a point in a shape from which *any* bisecting line divides the shape into two equal areas. No such point exists in a triangle.

Related to these models is Salop's circle model, where players can traverse the circumference of a circle but not move inside of it (i.e. the interior of the circle is effectively uninhabitable). For a two-player game where resources/habitability are uniformly distributed around (or within) the circle, (theorem:) Nash equilibria exist at all points for both players, including where A and B are in the same location.[5]

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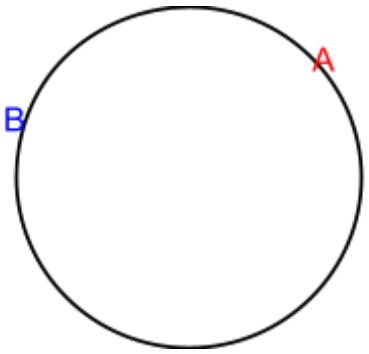
[4] The river generates "$21.4 billion annually from tourism, recreation and fishing... creating more than 300,000 jobs [in this sector]," accommodates manufacturing and shipping for several major firms, and its basin "produces 92% of U.S. agricultural exports," per Kingsley (2022).

[5] Applicable to other shapes as well when resources are uniformly distributed *around* the border of the shape.



Even as players increase (theorem:) Salop's model provides an infinite number of equilibria regardless of the number of players; players may be isolated in a fully symmetric arrangement (at distance 1/n from the next player), or symmetrically co-located in pairs when there is an even number of players (at distance 2/n from the next pairing).

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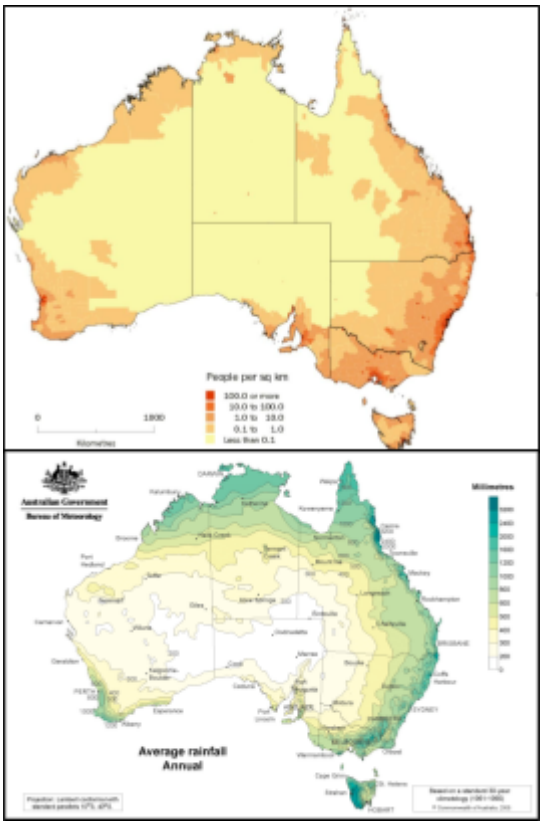
Case Study: Australia



95% of Australia is uninhabited, and 85% of its population lives within 50 km of the coastline. Its five largest cities alone (Sydney, Melbourne, Brisbane, Perth, Adelaide) account for the residences of nearly ⅔ of its 26 million people. And while Australia has more than enough arable land to support its low population—boasting 1.9 arable hectares per capita, the highest in the world—only 6% of its land is actually arable, per Lorelli (2022).

The centre of Australia is characterised by the arid and semi-arid Northern Territory and desert regions. Sparse rainfall is the product of (1) the cold Antarctic Circumpolar Current, which lacks the heat required for large-scale evaporation and subsequent rainclouds over the West, (2) the rain shadow cast by the Great Dividing Range in the East, which prevents moisture from penetrating the rest of the country, (3) its location straddling the subtropical high-pressure belt, which both warms and dries surrounding air, and various other geographical misfortunes. For these reasons, Australia's population density map mirrors its average annual rainfall map.[6]

Despite these challenges, Australia's population growth has mightily outpaced forecasts and is now projected to maintain its high growth rates over the next few decades.[7] The Australian Government's Centre for Population predicts the 30 million milestone to be reached in 2032-33—the majority contribution being migration from China and India. While this growth and demographic evolution will certainly bring changes to government, industry, and culture, its unique population distribution will, over the foreseeable future, persist for the aforementioned reasons.

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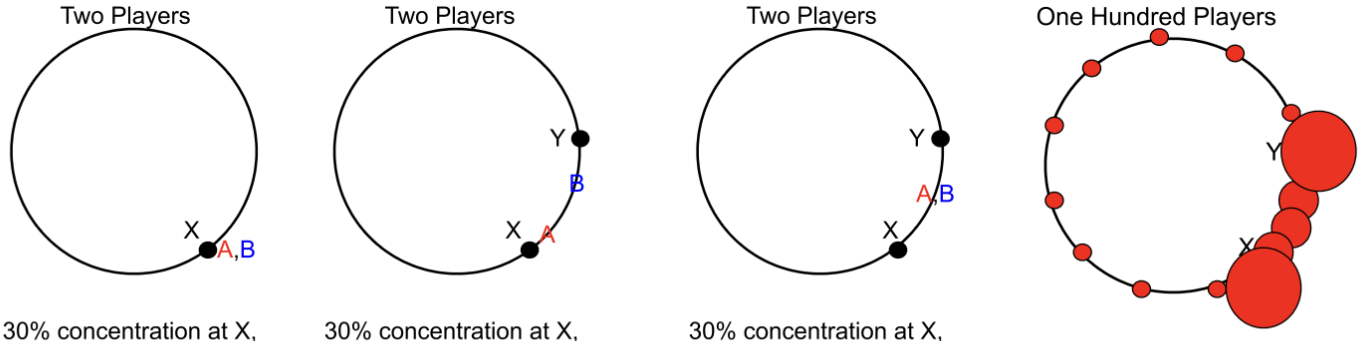
[6] Apart from the Northern coast, which receives up to 1800 millimetres of rainfall, almost entirely during a four month wet season from December-March. Its active monsoons and tropical cyclones during this period pose a different habitability problem than the rest of the country.

[7] "In 1998, the Australian Bureau of Statistics predicted that, based on low-growth assumptions, Australia's population would reach 23.5 million people in 2051, a benchmark it went on to achieve in July 2014," per mccrindle (2017).

* * *

Australia's structural similarity to Salop's model is evident. But there still exist clusters around this perimeter—areas of higher resources/commerce/habitability/overall desirability. To more precisely model Australia, I again relax the uniformity assumption from Salop's circle model. Adding 'concentrations' of resources at certain points around the circle has interesting implications for Nash equilibria.



Although non-uniformity disturbs the prior theorem, a Nash does exist in the last game of one hundred players.[8] But more importantly, as mentioned before, it is intuitive where relatively high numbers of players will be concentrated. And the rightmost model resembles the unique distribution pattern of Australia when picturing point Y as Sydney and point X as Melbourne. Similarly, there could be a point *Z* (Brisbane), of whatever unique concentration, and so on as concentrations of varying magnitudes lie around the border and the model showing location desirability becomes increasingly pragmatic.

Now, do we learn anything from these models? Or are they too simplistic to provide any revelation and lacking in impact? I note two things:

1. In both games with Nash equilibria and those without, the incentive to deviate to locations with better outcomes drives human behaviour. Maximising utility (or payoffs, or share of resources, etc.) is an offshoot of perhaps the most foundational human desire, self-preservation, as argued by Hobbes' social contract theory in *Leviathan* (1651). There are, of course, countless other sources of conflict in the practical world which are not factored into this model, but this illustration of game-theoretic strategy shows very fundamental, underlying reasons for geographical conflict and borderline instability.
2. In the real world, we often see clustering, as first noted by Harold Hotelling (1929). In particular, clustering occurs at game theory optimal locations, and these locations *are* the reason for the clustering. This appears in fast food chains, retail stores, car dealerships, gas stations, financial hubs, political elections, pricing, and certainly in geography. Players choose strategies similar to most any other game: they assess the strategy of others, payoffs, stability, and future outcomes.

Conversely, what faults exist with these game theoretic models? The primary discord is that games are generally non-cooperative—players are ultimately competing rather than cooperating. In contrast, geography is often very much an allied

[8] A solution which I spent an unreasonable amount of time working on, for no benefit other than personal satisfaction:
32 players at X, 32 players at Y, 18 players distributed in pairs at 1/10, 2/10, ..., 9/10 of the distance between X and Y in each direction.

effort. Cities are industrial hubs because commerce is profitable for everyone. Even if people are fundamentally and primarily self-interested, their 'being together' is mutually beneficial; self-preservation is the reason for society, as Hobbes notes. Geography is cooperative and therefore operates more like an 'assurance game,' or other games where cooperation is both Nash and Pareto efficient. However, in many other areas, achieving Pareto efficiency is a noble quest undermined by rational agents with common knowledge—shown by paradoxical games like the classic Prisoner's Dilemma.[9] As demonstrated in the next section, it becomes the role of governments and influential NGOs to 'change the game.'

II: Institutions

Nash-Traps, Gamemaker Responsibility, and Time-Discounting Combat

> *"If the misery of the poor be caused not by the laws of nature, but by our institutions, great is our sin."*
> *- Charles Darwin (1839)*

Often cited as the most important factor for cross-country income differences, it is uncontroversial that institutions play a role in a nation's success. Yet, the degree of influence is controversial. Part of the reason why: it is difficult to define and encapsulate *institutions*. Economic historian Douglass North (1990) describes institutions as "the rules of the game in a society or, more formally, [the] humanly devised constraints that shape human interaction." Perhaps North was discreetly professing his life's desire to be a development game theorist, or perhaps he just wanted to pave the way for future ones.[10] In any event, I thank him for his prophetic contribution to this paper.

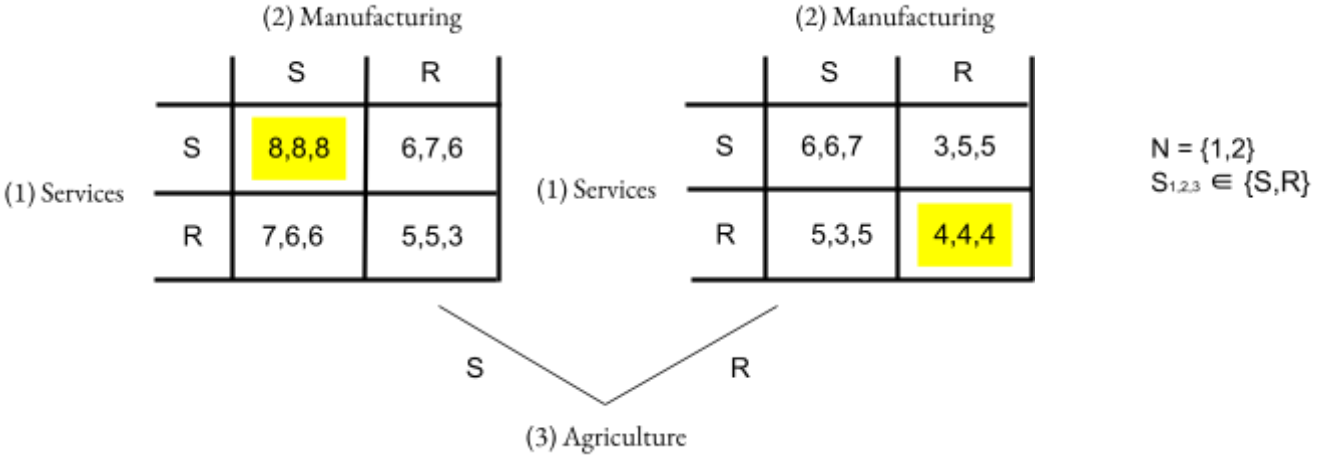
These institutions, or "humanly devised constraints," are malleable, or at least generally more convertible than a country's geographical or cultural makeup. Therefore, a country that performs relatively inefficiently or is otherwise seeking growth has in their toolbox an ability to change "the rules of the game." And while institutional change is sure to have winners and losers, an ultimate outcome of a higher level of development is a near-Pareto improvement. Yet, due to implementation lags and effect lags, transitory periods may have lower production, and citizens may suffer from lower quality of life during this transition. If lags are longer than the terms of government officials, then their work may be for nil as new political candidates promising a return to the 'good ole days' or an altogether different plan may replace them. Therefore, non-democratic governments or democratic governments with longer term lengths may be better-suited for change. Of course, these same circumstances could *cause* barriers to change, depending on the officials in charge, as shorter term lengths are more favourable for office-holders accountability and ridding of bad politicians. Gerbasch et al (2019) find contrasting forces in determining optimal term length, but their model overall rationalises longer terms when there is "high polarisation and/or social instability." While "polarisation"' is an inevitable consequence of social contracts and experienced by countries the world over, it is certainly not unreasonable to suggest that developing countries are more subject to "social instability."

At any rate, given the necessary time and resources to transition to better outcomes (some of which can be achieved with very little time and/or resource commitment), policymakers ought to strive towards this end. But countries get stuck. Poverty traps, technology traps, demographic traps, environmental traps, etc. hinder progress. And so it becomes the task of officials, the

[9] A game that shows two players acting in their own self-interest will not achieve an optimal outcome.
[10] Paving the way, i.e. recognizing that he had far more important responsibilities in the founding of institutional economics and cliometrics, work that earned him a 1993 Nobel Prize and guided his consulting with governments in China, Latin America, and new independent former Soviet states in Eastern Europe. Suffice to say, his decision to leave the study of games to undergrads with abbreviated attention spans was likely a wise one.

gamemakers, to alter the game to reach Pareto optimal equilibria. This can be accomplished materially through legislation, incentives, and subsidies, or psychologically through 'nudges.'[11]

One institution, relevant to both my current stage of life and the context of this project, is education. Consider a game like the one below:[12]



Here, there are three players which represent the three key sectors of an economy/contributors to GDP. Their corresponding number depicts their position in the payoffs. The strategies available to each sector are supporting (S) or rejecting (R) initiatives for higher education levels among students. In practice, this may involve a decision of whether or not to abide by higher minimum (1) education requirements among students and correspondingly (2) legal working age, specifically in countries where law enforcement is less dependable and self-governance more relied upon. Naturally, firms in the sectors prefer a lower minimum working age, which increases the supply of workers and likely lowers compensation requirements, in a labour-specific 'race to the bottom.'

Note two strict Nash equilibria (highlighted) in this game, and suppose we are currently at the bottom right one, (R,R,R). An overall substantial improvement in the education level of citizens could bring the country to a Pareto superior Nash, shown in the top left, (S,S,S). However, players acting in their own best interest will not find this equilibrium on their own (a common characteristic of paradoxical games). After all, supporting the higher education proposal puts a business at a competitive disadvantage. If agriculture (either a specific firm or a general sentiment of the sector) supports students furthering their education, but manufacturing and services do not, then agriculture will simply lose out on potential workers to manufacturing and agriculture (shown in (R,R,S)). Agricultural support of further education will hurt them by means of a decreased labour supply and higher wages, despite their best intentions. The same is true for services and manufacturing ((S,R,R),(R,S,R), respectively). If, by miraculous intervention, all sectors supported the proposed education act, then they would all operate at a higher level. Higher educated citizens lead to better government, better technology, and more efficient production.[13] But, as shown in the game, it benefits no one sector to make the first move; the country is stuck. It becomes the role of gamemakers to search for opportunities to alter the game so that the Pareto optimal outcome can be achieved.

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[11] Thaler and Sunstein (2008) describe nudges as the following: "Any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy and cheap to avoid. Nudges are not mandates. Putting the fruit at eye level counts as a nudge. Banning junk food does not."

[12] Known as an assurance game or stag hunt game, where there are two nash equilibria, one optimal and one sub-optimal.

[13] For instance, Casselli (2004) notes remarkably lower agricultural efficiency in poorer countries, despite poorer countries' much higher proportion of agricultural workers. Models used in the paper show that "if poor countries achieved the same level of agricultural labour productivity as the US, world income inequality would virtually disappear!"

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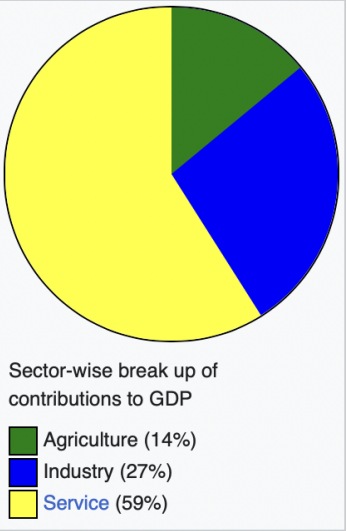
Case Study: India

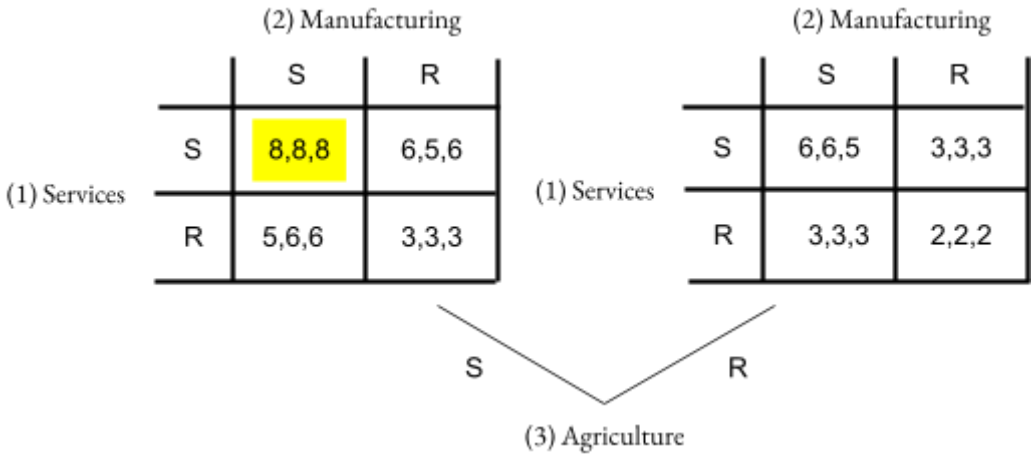


The fifth largest economy (by nominal GDP) in the world is a mixed middle-income social market economy that is characterised by three major sectors: Services, Industry, and Agriculture. The Indian economy is one of the fastest growing in the world, with the World Bank reporting 7.7% year-on-year growth in real GDP during the first three quarters of fiscal year 2022/23, in its latest *India Development Update*. Per capita income has nearly doubled in the last decade, and poverty has fallen dramatically. Notably, a more stable political environment and significant government expenditures in infrastructure have fostered growth and attracted investment, both foreign and domestic. This growth has been accompanied by a greater reach of education (higher enrollment numbers among children, more schools and universities, and increased funding). Yet, much of this educational 'progress' is specious. Underlying greater involvement and investment are poor, outdated structures: undertrained faculty, subpar infrastructure, and outdated curricula. Half of India's population is between the ages of 5 and 24, with over 27% of the population under the age of 14; no country has more young people. Many believe that a better education system will provide the boost India needs to reach its $5 trillion economic growth dream.

Fortunately, the Indian government is well aware of its tremendous growth opportunities and is implementing a new 5+3+3+4 pedagogical and curricular structure (formerly 10+2), embracing remote learning in rural areas, and creating jobs in local markets to prevent talent drain. Further, NGOs like Pratham are helping to renovate a tired system with high-quality, low-cost interventions to address education gaps founded on their "Teaching at the Right Level" (TaRL) approach. These efforts have significantly improved both student proficiency and commitment.

* * *

The Indian government and NGOs have made education a higher priority for students and their parents. While the effects of this effort may take time to realise, ultimately it keeps more students in school and out of the workforce at a young age. Consequently, businesses receive less benefit in drawing from a younger crowd for their workforce (lower supply, higher wages). Note the ubiquitous two-util drop from playing R:



With the shift in payoffs, it is no longer rational for any sector to reject education initiatives. The new wave of education has changed the game, and once businesses reap the rewards of a more educated population, they are sure to be on board.

Of course, an underlying game for the one above is the decision of the current students and their parents, whose prioritisation of education impacts the payoffs of the sectors. Among the factors that go into this decision for each student is the information available to them about the career impact of their deciding whether or not to drop out. In the Dominican Republic, this choice is made in the 8th grade.

* * *

Case Study: Dominican Republic

Education in the Dominican Republic is divided into four stages: Nivel Inicial (preschool), Nivel Básico (primary school), Nivel Medio (secondary school), and Nivel Superior (higher education). Primary and secondary school are free, though only primary school is compulsory. Categories of schools include private, polytechnic, and public non-polytechnic, with decreasing facilities and student performance, respectively. While university study carries its own set of challenges in the D.R., as noted by Louime et al (2022), recent efforts have been made to improve pre-university education quality and enrollment, including the *Dominican Republic Early Childhood Education Project* financed by The World Bank and a $200 million loan from the Inter-American Development Bank.

American economist Robert Jensen (2010) notes the distinction between returns (in later career earnings) to secondary school and perceived returns—the latter of these actually affecting schooling decisions. He finds that, compared to the relatively well-informed students of the U.S., 8th-graders in the D.R. overestimate earnings without secondary schooling and underestimate earnings with secondary schooling—the combined effect being a dramatic underappreciation of the returns of secondary school on career earnings. This results "in an undersupply of skilled labour, which in turn inhibits the development of domestic skill-intensive industries or the ability to attract foreign direct investment." Implementing an intervention program in schools that informed students of measured returns significantly increased average schooling. The increased demand for schooling from such an inexpensive program can be realised despite many resource constraints in developing countries. Still, Jensen finds the program had no effect on the poorest students, suggesting that information is an influential factor in deciding whether to continue schooling only for less-poor students. Essentially, there are factors other than information (poverty realities, credit constraints) that are preventing poorer students in developing countries from pursuing more schooling.

* * *

While students in high-income countries have a clearer picture of the outcomes of their choices, students in poorer countries are often subject to incomplete information and consequently misguided strategies. Specifically, in the Dominican Republic, students do not appreciate the association between secondary schooling and later-career income. Fortunately, as Jensen attests, better information can be implemented for minimal cost. Similar conclusions are presented in Kaufman's (2008) study of Mexico and Nguyen's (2008) study of Madagascar. In other words, we can likely make changes to current states just by giving players better information. In game theory, *complete information*, which Luce and Raiffa (1957) describe as a situation where "each player is fully aware of the rules of the game and the utility functions of each of the players," is usually assumed. In contrast, incomplete/asymmetric information can give rational, knowledgeable players advantages over rational, unknowledgeable players, and is a plausible explanation for 'the poor staying poor,' among other causes of poverty traps. Resolving cross-country income

differences could start with low-cost, easy-implementation programs striving towards complete information and subsequently common knowledge.[14]

Even though better information cures inefficiency in the student's strategy, it isn't a cure-all. Another key factor that goes into the student's decision is the income level or socioeconomic status of the student's family, as found in Jensen's work. The information program had a significant effect on the least poor students, but next to no effect on the poorest students, showing that there are essential factors other than information (poverty realities, credit constraints, preparedness) that prevent poorer students in developing countries from continuing schooling.

A final key factor that goes into each student's decision, and is particularly compelling from a game theory perspective, is how much they discount future income relative to current income (e.g. next year's payment vs this year's). Based on the survey of perceived returns to secondary school, Jensen asserts "If we assume that students expect to work until they are 65, and have a discount rate of 0.05, even if there were no direct costs of schooling, the implied net present value of the lifetime expected stream of earnings without secondary school is 11% *greater* than with secondary school." This part of the decision, the rate of time preference, is highly personal, although it gives context to the decisions we see among the uninformed students. Mexico's PROGRESA program attempted to draw on both of these latter decision factors.

* * *

Case Study: Mexico

Mexico ranks last among OECD countries in student reading literacy and maths and science scores. According to the OECD's Programme for International Student Assessment, the poorest children in Vietnam outperform the most privileged students in Mexico. Even so, Mexico is the second most unequal country according to the OECD's November 2016 Income Inequality Update; especially dismal education statistics in poorer communities serve as proof. Underlying reasons for Mexico's poor educational state are the reality of poverty constraints for 15-18-year-olds, socioeconomic separation and barriers between indigenous communities and non-indigenous communities, shrinking budgets, and structural inefficiencies.[15]

In 1997 Mexico implemented a government social assistance program that provided conditional cash transfers (CCT) to eligible families for ensuring children attended school and received regular preventative health care. Eligibility was determined by (1) selection of communities from a census-based index measuring economic marginality, (2) selection of households using socioeconomic data, and (3) validation of household selections at town meetings. Ultimately, PROGRESA (later made *Oportunidades* and *PROSPERA*) significantly increased secondary-school enrollment of boys and girls. Skoufias (2005) asserts, "Most of the increase in school attendance is attributable to children, especially boys, working less to earn money for their families. The results imply that children will have, on average, about 0.7 years of extra schooling because of PROGRESA. Taking into account that more schooling is associated with higher levels of income, the estimations imply that children will have 8 per cent higher lifetime earnings due to the education benefits they have received through PROGRESA."

2.6 million households—ten per cent of all Mexican families and one-third of rural families—were beneficiaries of PROGRESA, which cost nearly 0.2% of Mexico's GDP. Initially, households received 90 pesos monthly pending proper compliance. Only one per cent of families were ever denied the monthly transfer (which might suggest either remarkable efficiency in the program or remarkable inefficiency in the compliance monitoring). The World Bank described PROGRESA as a

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[14] A condition one step stronger than common knowledge, requiring all players to be rational: information is not only known, but known to be known by other players, and known to be known to be known, *ad infinitum*. It is usually assumed in game theory and is the basis for Nash equilibria. The mathematical formulation for common knowledge, which is now the standard in economics, can be attributed to Robert Aumann (1976).

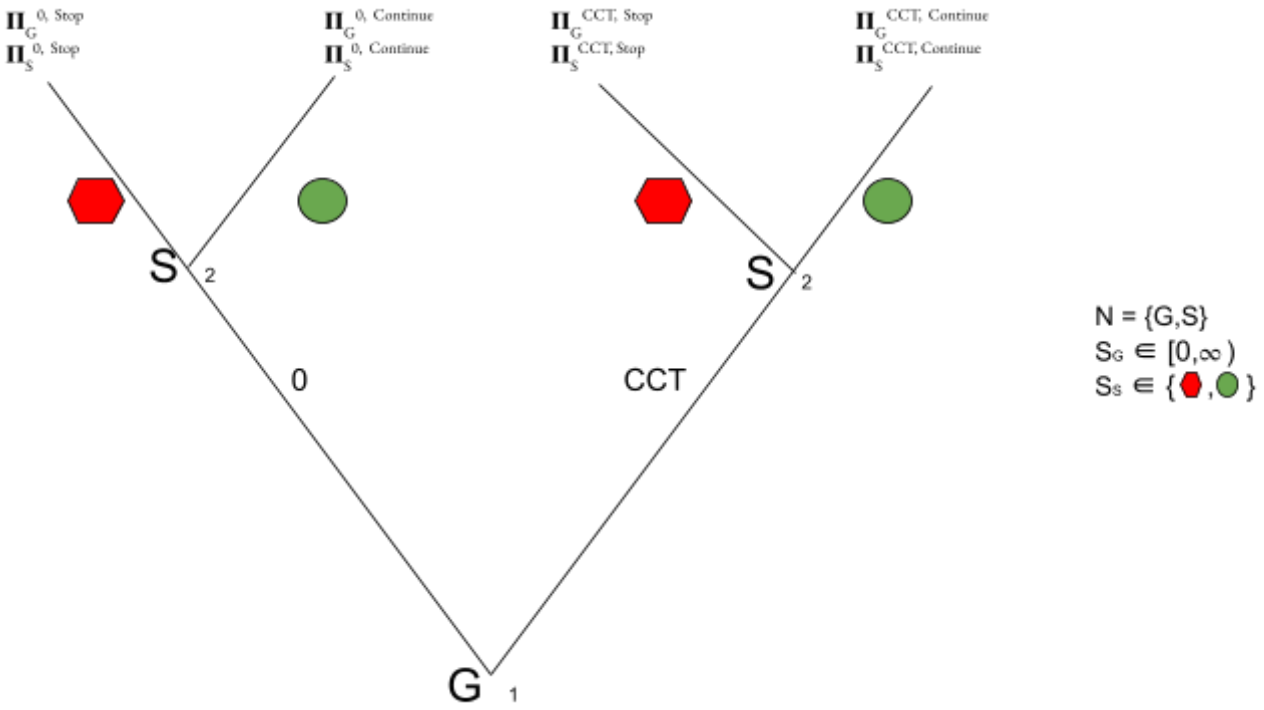
[15] According to a 2017 article by Nina Lakhani of *The Guardian,* "1.3 million school children around the country use indigenous dialects as their first – and sometimes only – language. Only 60% of the 55,000 teachers who do speak an indigenous language are in classrooms where students speak the same one."

"Model from Mexico for the World." Ultimately, funding for the program was cut in 2019. Still, its impact in Mexico is undeniable and its legacy continues as a model for similar programs in more than 60 countries.[16]

* * *

It might be hard to psychologically alter an individual's discount factor in the long term. Particularly, impatient children and their poverty-stricken families who survive 'paycheck to paycheck' might intrinsically have pretty strong preferences for money now. In contrast, the government is ideally far more patient than its citizens.[17] The Mexican government's solution to this problem is a clever one, taking advantage of its relative patience in reaping the future rewards of more educated citizens, by giving relatively impatient citizens much-desired cash incentives.

Suppose a child reaches an age, a minimum working age, that at any moment they can drop out and receive a certain monthly salary; In Mexico, this age is 14. Conversely, they can continue schooling where, upon completion of secondary education, they are sure to receive higher income. Now the government and the child play a sequential game (below), where the government acts first by choosing a monthly stipend, CCT. The student (and their family) can subsequently choose whether to accept the offered CCT (continue schooling, green light) or to reject and begin working (stop schooling, stop sign).



First, note a few things:

(1) The government will (in a world of perfect discrimination) not offer a CCT to a student that would opt to continue schooling anyway. That is, G chooses 0 if $\Pi_S^{0,\ Continue} > \Pi_S^{0,\ Stop}$. (This type of discrimination practically may not be possible, or fair).

(2) Any particular student will continue schooling as long as the CCT is high enough s.t. $\Pi_S^{CCT,\ Continue} > \Pi_S^{CCT,\ Stop}$.

(3) The Government will only offer a CCT if it is feasible for them to do so, otherwise, they can offer no CCT (leftmost).

How will they know if they can offer a CCT and, further, what CCT to offer? The government's first goal is to satisfy the

[16] Per Parker and Todd (2017).

[17] Again, this is where optimal term lengths and the tolerance for transitory periods becomes relevant.

following inequality: $\boldsymbol{\delta}_G * I_F - CCT \geq I_c$.[18] This means that, during a given month, the future income earned by the current student multiplied by the government's discount factor and subsequently reduced by the proposed CCT must be greater than or equal to the income the child would otherwise receive if they started working immediately—they seek to maximise the LHS. The government is foremost making an investment in each student that will pay off in the long term. But in order for the student and their family to accept the proposed CCT, it must pay off for them as well. The student and their family will accept iff $\boldsymbol{\delta}_S * I_F + CCT > I_c$.[19] Hence, the government will offer a CCT if these two conditions hold and then will maximise their LHS, conditional on the student's requirement being met.

Per trading economics, the average monthly salary in Mexico at the time of PROGRESA's introduction was 3932.27 MXN.[20] Using figures borrowed from Jensen's work in the D.R., roughly 25% of the Mexican population at this time was secondary-school-educated, and that population made, on average, 40% more than the non-secondary-school-educated population. After some algebra, it comes out that the educated were making, on average, 5004.71 MXN/mo. while the non-educated were making 3574.79 MXN/mo. These figures will be used for I_F and I_c, respectively.[21] At the time of the program's implementation, the Mexican government would have used these figures and their patience (+present bias, etc.) to find their optimal CCT. In the case of a post-program analysis, looking back into history, I will use the determined 90 MXN CCT to back out their $\boldsymbol{\delta}_G$. Doing so produces $\boldsymbol{\delta}_G \geq 0.732$. Doing the same for the student equation produces $\boldsymbol{\delta}_S > 0.696$. If, as previously hypothesised, the government maximised their payoff, then the student's discount factor would be just larger than 0.696 (such that 90 MXN is the minimum monthly payment the families would accept), and the government's discount factor anything equal to or greater than 0.732. As one would expect, the government is more patient than the citizens (less discounting of the future). The student's family is likely getting scalped of potential surplus, but they will choose to continue schooling so long as the payoff from doing so marginally outweighs the payoff from beginning work. The government knows this, and through backward induction, proposes the minimum CCT that the student's family will accept.

Is this greedy of the government? It is difficult to say. On the one hand, the government is justly taking advantage of its relative patience to financially assist students in their long-term schooling decisions, even if marginally. On the other hand, it could be argued that the government has a responsibility to be of greater service to its citizens, such that more of the surplus from the preceding game ends up in the hands of the people (such that the proposed CCT should be more generous). How much economic surplus the government is entitled to is fundamental to any person's political ideology. Thus, 'gamemaker *responsibility'* guiding states toward *optimal* outcomes is still open for interpretation, specifically regarding the precise determination of *optimal* allocation and fair payment to the government for this *responsibility.* For moral discussion of these topics, you will need to look elsewhere.

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[18] $\boldsymbol{\delta}_G$: Government discount factor
I_F: Student's Income upon secondary school completion (per capita)
I_c: Student's Immediate Income without secondary school completion (per capita)
CCT : Proposed Conditional Cash Transfer

[19] $\boldsymbol{\delta}_S$: Student discount factor

[20] For reference, this is roughly equivalent to 579 GBP today, adjusted at the time of writing (mid-May 2023).

[21] In reality, a higher saturation of secondary-school-educated labour supply could lower wages (think shift right in labour supply). At the same time, higher education could lead to overall higher development outcomes and be a Pareto improvement (as shown earlier in section). In this simplified example, I assume they cancel out.

III: Culture

Conflict and its Consequence

> *"Go therefore and make disciples of all nations, baptising them in the name of the Father and of the Son and of the Holy Spirit, and teaching them to obey everything that I have commanded you. And remember, I am with you always, to the end of the age." (Matthew 28:19-20, KJV).*

Culture is objectively harder to assess and even morally harder to make judgements about than geography or institutions. Diversity of culture contributes to the beauty and intrigue of the world; most people and governments (with good sense) would avoid disturbing this aspect of another. But while morally we may avoid altering it, we should not be hesitant in analysing it: culture is an essential component of development and has great explanatory power for cross-country development differences. Some may argue that such research may inevitably compel people to change their culture. While the situation is complex, I am generally of the belief that better information ought not to be withheld from rational players—accurate research on the culture-development connection should only be a factor in an individual's optimisation decision. If one decides their quality of life would be better in abandoning a way of living for another, that is their prerogative. And considering the attachment people have to their culture, the incentives to change would have to be more than significant.

Acemoglu (2009) notes two major channels in which culture affects economic outcomes: "First, it can affect the willingness of individuals to trade-off different activities or consumption today versus consumption tomorrow... [influencing] occupational choices, market structure, saving rates and their willingness to accumulate physical and human capital." Here, note the relation to the last section's discussion of discount factors, which are difficult to meaningfully change (thus, rather than attempting to change a patience level a government may opt to supplement income). Culture is deeply ingrained in an individual—more meaningful and personal than geography or institutions—so, it is no wonder that individual discount factors are difficult to alter. Second, Acemoglu proposes, "Culture may also affect the degree of cooperation among individuals... play[ing] an important role in underpinning productive activities and thus affect the growth performance of societies." And, per Acemoglu, "Differences in religious beliefs across societies are among the clearest examples of cultural differences that may affect economic behaviour."

McCleary and Barro (2006) claim that religion has a two-way interaction with political economy: how development and institutions affect religiosity (where religion is a dependent variable), and how religiosity affects economic performance (religion as an independent variable). Pertaining to the second interaction, they find religious attendance significantly detracts from economic growth, while "belief in hell" significantly contributes to economic growth, notably through the effect of each on work ethic. Essentially, "Growth is enhanced when the religion sector is unusually productive in the sense that output (belief related to an afterlife) is high compared to input (attendance). Given beliefs, more time and resources spent on formal religion can be viewed as a drain on resources, which detracts from market output (GDP)."

Unfortunately, cultures come into conflict. In these cases, cultural structures play a game of survival—similar to the interaction of animal species in the process of natural selection. It was for this latter application that Maynard Smith and Price (1973) advanced evolutionary games to the delight of biologists and economists everywhere. As well as evolutionary biology, these games aptly model development. In development economics, we can think of competing forces/players as different (and sometimes opposing) cultures, mindsets, religions, or languages. Will there be an undisturbed equilibrium? Will there be conflict and a takeover? Which cultures are immune to which others? History gives us fascinating test trials for these questions. But before examining applications, it may be helpful to introduce/recap the game style:

In evolutionary games, the players do not choose strategies, but rather they are the strategies. At any outcome, we are modelling the interaction between two of these (same or different) strategies. Evolutionary games are symmetric by nature. Deviations in strategy are dictated by immunity, defined as the following:

Strategy p is immune to strategy q iff:

$\mathbf{\Pi}(p,p) > \mathbf{\Pi}(q,p)$, or

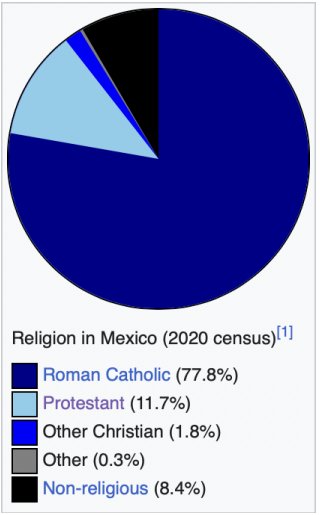
$\mathbf{\Pi}(p,p) = \mathbf{\Pi}(q,p)$ and $\mathbf{\Pi}(p,q) > \mathbf{\Pi}(q,q)$

An evolutionary stable strategy (ESS), p, is one that is immune to all other strategies, q. Thus, an incumbent species (or civilization, or culture, or religion) will only persist in conflict if it is immune to intruders.

Now, we can model cultural games.

* * *

Case study: Mexico



In 1519, Hernan Cortés arrived in modern-day Mexico with a band of 500 Spanish soldiers, hired slaves, and others of varying commitment levels to his conquest. Outnumbered by the indigenous Aztec population and worn from the voyage, morale was certainly low. In an all-time strategic move, to prevent his group from abandoning the effort, Cortés purposely sank the ships they arrived in and restricted the choice set of his army: fight or die. Manipulation, exploitation, and brute aggression subsequently directed towards the native population granted the Spaniard success in his conquest—namely after the fall of Tenochtitlan in 1521.

Christianization, like the original conquest, was driven by further manipulation, exploitation, and aggression. Cultural diffusion, miscegenation, disease, and plundering acted on an already defeated people. Tonantzin, or "Mother Earth," was substituted by the Virgin Mary, churches were built on temple ruins, missionaries kidnapped children and indoctrinated them in the Christian faith, and Spanish blood was promoted as more dignified than native blood. As missionaries soon struck out from Mexico City to reach more indigenous populations, the spread of Christianity was rapid.

Christianity's stronghold on current-day Mexico can be characterised by the following: roughly 80% of the total population practices Roman Catholicism, making it the world's second most catholic country (behind Brazil). The remainder is composed in majority by Protestantism caused by Anglo-American interaction in the early 19th century.[22] Its national history, such as the movement against slavery and its independence, is intertwined with Catholic inspiration, as are festivities and holidays like All Saints' Day, All Souls' Day (Day of the Dead), Christmas, and Easter.

* * *

Christianity is a universalizing religion. The goal of its disciples is to make more disciples, in all corners of the Earth. So, with colonisation came Christianization. Rodney (1972) contends, "The Christian missionaries were much part of the colonising forces as were the explorers, traders and soldiers. There may be room for arguing whether in a given colony the missionaries brought other colonialist forces or vice versa, but there is no doubting the fact that missionaries were agents of colonialism in the practical sense whether or not they saw themselves in that light." Clearly, in Latin America, this effort was triumphant.

[22] Less affectionately known as the Mexican-American war.

	Christianity	Aztec Polytheism	Inca Polytheism
Christianity	1,1	3,1	0,0
Aztec Polytheism	1,3	2,2	4,1
Inca Polytheism	0,0	1,4	4,4

Latin America

$N,S = \{C,A,I\}$

In the game above, consider Aztec and Inca polytheism to be incumbent religions subject to the intrusion of Christianity. A variety of weak Nash equilibria, which lack staying power, are overcome by one ESS: Christianity. Here, Christianity is the only religion with immunity against the other two. So, (C,C) becomes a dominant strategy and resting place. Despite inhabitants who may be allured to other places on the matrix with higher payoffs (i.e. other religious practices), these cannot be achieved with the introduction of Christianity—formerly dominant religions are no longer stable, and moreover, are vulnerable to the presence of Christianity. This begs the question: What happens in instances of religions that, for whatever reason, are less vulnerable? What happens when a universalizing religion takes on another universalizing religion that is already established?

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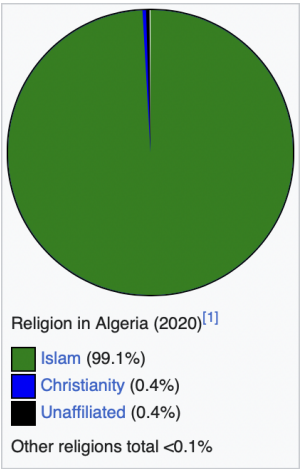
Case study: Algeria



In the 7th and 8th centuries, Arab conquest of North Africa resulted in large-scale Islamization. In Algeria, pockets of Berber mythology, Judaism, and Roman Catholicism were quickly supplanted by the new ideology and gave way to fresh Berber dynasties that dominated modern-day Morocco, Tunisia, and Algeria through the 15th century. At this point, further Arabization dismantled the Berber dynasties and made Arabic the dominant language amongst the Berber population.

The Roman Catholic church was reintroduced in Algeria during French colonisation in the 19th century. Although the French colonial regime was determined to undermine Muslim Algerian culture and proselytization was attempted, few conversions took place. A long decolonisation process and harrowing war led to Algeria winning independence from France in 1962, where Islam was a central component of the resistance movement. A strong Islamist national identity has since been employed essentially as an institution, being used to combat socialism, more liberal family structures, and other religions.

Today, over 99% of all religious adherents in Algeria practice Sunni Islam, and similar figures exist throughout North Africa. The grip that Islam has on these countries is immense. In Tunisia, freedom of religion is stifled by societal pressure against Muslims leaving the religion and institutions maintaining the state as a "guardian of religion," including a constitutional stipulation that the president must be Muslim. In Libya, Salafist militant groups exert pressure on religious minorities to convert

or revert to Islam. In Algeria, feminist efforts fall by the wayside when they reach Islamists' radars. The draconian laws and practices accompanying religion in these countries hamper the expression of different cultures.

* * *

For North Africa, observe the following game between religions:

	Christianity	Islam
Christianity	2,2	1,2
Islam	2,1	2,2

North Africa

N,S = {C,I}

Here, notice both (C,C) and (I,I) are Nash, and that a heterogenous population is never a permanent outcome. But, by the rules of immunity, only Islam is an ESS and able to fend off Christian expansion, not the other way around. In particular, if we are already at the (I,I) state as opposed to the (C,C) weak equilibrium, then there will be no movement. This is the case in North Africa, where Islam is the incumbent to Christian intrusion, and Christian conversion efforts fall flat.

In Sub-Saharan Africa, a different situation currently exists where similar proportions of Muslims and Christians live among each other. Both religions have seen rapid growth since 1900 in the area once penetrated by Traditional African religions. However, this growth and consequent control by both religions have led to frequent religion-centric conflicts. According to Pew Research Center (2010), "Substantial numbers of Christians (ranging from 20% in Guinea Bissau to 70% in Chad) say they think of Muslims as violent. In a handful of countries, a third or more of Christians say many or most Muslims are hostile toward Christians, and in a few countries a third or more of Muslims say many or most Christians are hostile toward Muslims." Nigeria, for instance, is a secular state with no official religion. Currently, 51% of the religious population is Muslim and 47% of the country is Christian. This heterogeneous growth has been accompanied by inter-religious conflict in the form of massacres, banditry, kidnappings, and riots. Pew Research (2010) rated Nigeria second-highest in social hostilities among the world's 25 most populous countries. In other words, it's unlikely that the structure of religion in Nigeria, in its current form, is evolutionarily stable. Will Islam win out as it has in North Africa? Or will different underlying circumstances lead to Christianity being able to sustain itself?

And zooming out again: *Is Christianity dominant*? The answer is sometimes. In Latin America: Yes. In North Africa: No. In Sub-Saharan Africa: It remains to be seen. What kind of factors underlie the success of the religion and its interaction with other religions is a separate and complicated discussion, but anthropologically and philosophically interesting. Perhaps it has to do with the attached culture and motives of the intruder or the incumbent, such that Spanish colonisation was more effective than the French effort, or that the Mesoamerican civilizations were more vulnerable to conquest than North Africans. Van Oss (1986) observes, "Unlike such other European colonising powers... Spain insisted on converting the natives of the lands it conquered to its state religion. Miraculously, it succeeded." Success is largely a game of matchups, in sports and in colonisation. In its conquest of Latin America, Spain tactically weaved Catholicism into Incan polytheism. Christian beliefs were added to Andean traditions in simultaneous language-religion integration. Islam in North Africa was hardly receptive to such doctrines: Speel II (1960) claims Islam offered a faith which was closer to the Teutonic Arianism of the Vandals, as opposed to the anomalous Catholic Christianity, where transition would have always posed unconventional barriers for inhabitants. In any case,

the overall aggression level of the religion certainly plays a role also, and when two aggressive (universalizing) religions match up, the country may not be big enough for the both of them.

At this point, religions have been modelled in evolutionary games and different types of immunities depicted. But what does all of this mean for development? Coming full circle, religious presence in a country (or lack thereof) has implications for growth and development, as noted early in this section. Religion in general can be both a distraction from work (via service attendance, worship, prayer) or a motivation for work (via karma, afterlife judgement). Furthermore, specific religions have varying degrees of each channel and consequently deserve credit for explaining income differences. The 'high output, low input' religion that McCleary and Barro describe as economically superior is evidence of a religion's direct effect on development. Additionally, religious perspectives indirectly (through doctrines, lifestyles, attitudes, etc.) influence poverty levels, inequality, education, nutrition, and more evaluators for development level.[23] Finally, the conflict of religions has obvious ramifications for growth, as supported by Reynal-Querol and Montalvo (2000), whose models show religious polarisation (rather than religious and ethnolinguistic fragmentation) has a strong and negative effect on growth through the investment rate, government expenditures, and the probability of civil wars, and is an important explanation for "Africa's growth tragedy."

The 'high output, low input' religion may be optimised for GDP. But is it optimised for happiness or immeasurable quality of life? Who am I to argue that one's religion is optimal or not? The analysis presented only evaluates religion's impact in terms of empirical economic performance. In doing so, I realise that religion, for its members, is not a means toward an economic end but rather is itself meaningful. And for adherents who are content, there exists no justifiable incentive to deviate.

Other aspects of culture may be just as important as religion from a development perspective. Research suggests that more "ethnically diverse societies are prone to corruption, political instability, poor institutional performance, and slow economic growth," per Miguel (2004). To combat ethnic divisions, Tanzania has leveraged a national identity that fosters better community among its diverse districts: "Tanzanian leader Nyerere forcefully downplayed the role of ethnic affiliation in public life and instead emphasised a single Tanzanian national identity. A founding principle of Nyerere's ruling TANU political party was 'to fight tribalism and any other factors which would hinder the development of unity among Africans.'" In contrast, a lack of national pride has allowed ethnic divisions to cripple civic life in similar communities just across the border in Kenya. The cultural-institutional transformation in Tanzania—"the promotion of Swahili as a national language, political and civic education in schools, the dismantling of tribal authorities, and the relatively equal regional distribution of resources"—has charged the nation's growth (now among the top in Africa).

Whether religion, language, national identity, or all of the above, the direct and indirect impact of culture on production and progress is significant. While research on culture (hopefully of which there is more to come) must stay descriptive rather than normative, it certainly provides key insights into cross-country differences. Moreover, it may lead to roundabout ways (i.e. through institutions) to enhance growth while maintaining current cultural frameworks, as was done in Tanzania.

[23] Although most research now recognizes the impact of aid on growth and subsequent poverty reduction, the long-term effect of charity on poverty rates, inequality, etc. is still dependent on good policy and the source/circumstances of the aid granted. See Masud and Yontcheva (2005) and UNU-WIDER (2005).

Part 3: Conclusion

As with many other applications of strategic decision-making, game theory is applicable to development economics. I am not sure why the attachment of these two disciplines is so underrepresented (or at least not explicitly linked). Perhaps the general notion of games being competitive models goes against the ethos of much of development theory, which seemingly centres on cooperative, assistive research and subsequent provisions to diminish cross-country income differences. While it *is* encouraging to model development problems in cooperative frameworks, it *is not* comprehensive. A thorough approach to development theory must propose solutions for the future while addressing shortcomings of the past and especially recognising the fundamental roles that rationality, information, and competition have in such shortcomings. Game theory is useful in this context.

In geography, cooperation is evident: civilization is mutually beneficial for all participants. Nevertheless, distributions of resources (or overall desirability) create both (1) clustering and (2) conflict for agents looking to maximise payoffs. At higher concentrations of desirability, this clustering is fascinating, while the unwavering conflict is frightening. The world presents an endless set of options to autonomous players, and each player is working towards a game theory optimal strategy. Location models like Hotelling's, Salop's, etc. serve as a useful tool in analysing this condition.

Action within institutions, particularly for business and industry, is usually a very competitive effort. The same is often true at a macroeconomic scale, and unfortunately, competition can place countries in development traps—even if players have accurate information and common knowledge. In many cases, officials, both government organisations and NGOs, possess the power to change the game and escape the trap. To solve traps and achieve Pareto optimal outcomes can often require peeling back the layers of the 'economic efficiency onion.' Underlying one game is another, and underlying that game may be another. Nearly all development games are influenced by education–its significance makes it worthy of the attention it receives. By changing the structure of related or subservient games (like education), improvements in income, GDP, quality of life, etc. can be obtained.

Culture is often underrated as an explainer of development. Perhaps this is because it is tricky to evaluate in models, or perhaps because comparing cultures seems taboo. However, this should not be the case. Ultimately, culture can be evaluated objectively and meaningfully while recognizing that more goes into an agent's cultural subscription function than expected income. And whether the economically superior culture is the most fulfilling one is a highly personal and highly unanswerable query. Finally, while it may seem heedless to construct deplorable colonisation and conflict in 'games,' game theory's capacity to model market/social/development outcomes should be valued, sometimes in spite of its fun-loving name.

Game theory *is* fun, and it is also important, both for its insight into historic affairs and its potential to explain future ones. Its integration with the widespread puzzles posed by development produces outcomes that are almost as captivating as their real-world counterparts.

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