Computational Strategy Formulation for Public Administration:

An Agent Base Modeling Case – Innovation Policy, Immigration & Develoment Economics a GCC Perspective

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ABSTRACT. Public administrations are facing an increased demand for effectiveness, as the administrational behavior has divided the concept into two main parts—one is decision— being arrived at and process of action. Mere making of decision is not enough and therefore its the implementation and therfore the results being thought what becomes influencial. Since the implementation and results are dependent on the tools being excercised, public administration through policy formulation becomes the focul pointfor inquiry. Policy is at times simple, but mostly complicated, complex, and chaotic; such classification makes policy research a prime candidate for complexity theory and the integration of complexity methodologies in public policy research. Complexity science is primarily concerned in accounting for complexity in varied contexts, on varied scales, and with an interrelated and interdependent actor's and environment. It is proposed that complexity mythologies combined with traditional qualitative and quantitative methods can bring to light the clockwork of the elusive black box of complex systems. Recent studies suggest that it would be appropriate to use complexity based tools as an extension of exploratory analysis; Agent-Based Modeling, was therefore chosen since such type of analysis generates ensembles of alternate plausible representations of future system conditions. User expertise steers interactive, stepwise system exploration toward inductive reasoning about potential changes to the system. In this paper, we develop an understanding of a potential alternative to policy formulation and evaluation methods, by way of successive simulations that test variations in the types and numbers of policies variables. To demonstrate the use of the proposed method a Wage Setting Policy for migrant workers was evaluated. In developing nations, Innovation is at very premature levels, and with the world economy becoming a knowledge base economy, the model addresses workers skills attainment and migration of skilled labor patterns and the effects on a certain economy. The interaction between three types of economies was modeled, a labor supplier developing the economy (India), a transient labor expelling developing economy (Qatar), and finally a developed high-skill labor magnet economy (Canada). Our investigation will focus on the transient expelling economy, Qatar. Controls were introduced as a preservation method of policy objectives. This exploration of alternative policy scenarios suggests that policy's economy of scale, environment interaction, and emerging behaviors all constitute an empirical need for a multi-facet policy and more significant role of Agent-Based Modeling (ABM) for a dynamic public policy formulation approach that may be utilized to address each emerged scenario and phase of policy execution.

Key Words: *Agent-Based Modeling*; *Public Administration; Policy; Innovation; Strategy Evaluation; Computational Policy Formulation.*

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Section 1 Introduction

In Public Administration, Herbert Simon defined Decision-making as the process or sequence of activities involving stages of problem recognition, search for information, the definition of alternatives and the selection of an actor of one from two or more alternatives consistent with the ranked preferences, in terms of efficiency[1]. H.A. Simon also divided the Administration behavior as a concept into two main parts—firstly, the decision— being arrived at and process of action, Secondly – implementation, as Mere making of decision is not enough (Simon, 1948:1997); since it's the result that is the functional result being thought.

Since assets, intangible yet created asset, such as Information and Knowledge of all kinds have become increasingly more important in all dynamics aspects of the economic space (Park, 2001). The ongoing debate of public policy formulation all strategize makers need to evaluate a given policy, in this a central question must be addressed: "How the economic agents are directly affected by the policy expected to behave?" As emerging behavior being the key outcome of policy formulation, which by definition does not dictate how an economic agent should behave, but rather attempt to influence the criteria by which its decisions are made[2]. Such policy measures may include financial incentives for new investments in human capital for ultimately gaining knowledge and retaining it, elimination of the brain drain phenomena, and removal of financial barriers, for the creation of new markets – and thus new business opportunities (Requate, 2005). Consequently, the best chance a policy measure has in order to attain its goals stems from its ability to align the public and private interests. This premise originates from (Flamos and Begg 2010) and (Robertson 1956) and the idea that effective policies capitalize on resources necessary for market influence. Under this perspective, an agent-based modeling for the purpose of policy evaluation can outperform other approaches in policy evaluation techniques in that it explicitly models economic agent's behavior (i.e. organizations) decision-making process and criteria can be captured. The main argument behind the adoption of policy setter's point of view in understanding the drivers and triggers of their decisions allows assessing both the strength (i.e. ability to overcome inertia due to uncertainty) and direction (i.e. characteristics of the induced behavior) of the incentives exerted

[1] In a for-profit organization, the "criterion of efficiency" states than an individual will select an alternative that will maximize income and minimize cost so as to "yield the greatest net (money) return to the organization". More generally (i.e., to include nonprofit organizations) the criterion causes "that choice of alternatives which produces the largest result for the given application of resources. Simon counters criticisms of the efficiency criterion and outlines methods by which efficiency can be attained (e.g., by "functionalization" and by the public budgeting process). A concept Simon identified in his Chapter IX. The Criterion of Efficiency

[2] As summarized by Simon in the 4th edition's, the central idea is that "the survival and success of organizations depend on their providing sufficient incentives to their members to secure the contributions that are needed to carry out the organizations' tasks"- a concept Simon identified in his Chapter VI. The Equilibrium of the Organization

by the investigated policy measures. This approach to policy measure evaluation is aligned with the Lucas critique (Lucas, 1976) which suggests that if we want to predict the effect of a policy measure, we should model the "deep parameters" (relating to preferences, technology, and resource constraints) that govern individual organization's (Agent's) behavior. We can then predict what individuals will do, taking into account the change in policy, and then aggregate the individual decisions to calculate the effects of the policy change. Moreover, the adoption of a "private actor point of view" approach facilitates addressing research questions such as the following:

RQ1. How can incentive policy facilitate skill attainment by influencing workers decisions?

RQ2. How can immigration policies direct to (Skilled Labor) into engaging in the current economy?

RQ3. How should the policy be designed to incentivize Economic Agents in participating in Innovation?

RQ4. How can incentive based employment policy facilitate overcoming risk concerns with the brain drain of skilled labor?

RQ5. How does the impact of a policy instrument differentiate between dominant market players with existing and new entering agents? Consequently, how is the policy instrument expected to affect the evolution of the market structure?

In response to the above issues, this paper aims at providing a novel agent-based modeling approach as a policy formulation and evaluation tool on the macro level in an attempt to explore the principle dynamics of an economic system with emphasis on the private actors' (Agent's) point of view and the impact different wage-setting policy instruments may have on the decisions of private actors with different characteristics, and how the emerging behavior impacts the overall economic emerging behavior of nations. The paper also considers alternative public policies pertaining to immigration and impact of such policies. The paper is organized as follows: Section 1 an Introduction, Section 2 a literature review, a description of complexity Science; a description of innovation and its role in strategic Public Administration, Brain Drain and its implications on the Economy as a problem and finally identifying the Agent-Based Model components from an Immigration Policy perspective. In section 3 a discussion of the model execution to identify emerging behaviors and conduct sensitivity testing. Finally, in section 4, a representation of the Discussion & Recommendations will be provided.

Section 2 Literature Review - Innovation, Public Administration and Computational Policy Analysis

Classical economists collectively drew a pessimistic picture, with economic growth inescapably constrained by decreasing returns to capital and limited resources. Such paradigm wasn't until more recent times – following the Schumpeterian legacy and the developments of modern growth theory – that the paradigm shifted and the evolution of technology started seeping into the field and began to be formalized into economic models.

In the knowledge era, the creation of economic value is based mainly on intellectual capital (IC) (Uziene & Stankute, 2015) and ability to… (McGrath, 2001). Knowledge becomes the central resource in today's fast-paced economy (Stewart, 1997). Together with innovation, it presents new force for gaining economic wealth in the knowledge era. IC encompasses three interrelated components: human capital (HC), structural capital (SC) and relational capital (RC) (Bontis, 1998) HC consists of various human-based resources and capabilities including experience, skills, competencies, attitude, intuition, creativity and innovativeness of people. SC is the non-human knowledge which lies in databases, processes, strategies, routines, organizational culture, brands and copyrights (Guthrie, Petty, & Ricceri, 2006)). RC represents a company's relations with its external stakeholders and their perceptions about it (Bontis, 1998).

Schumpeter recognized and coined the concept of "innovation" as an economic driver of competitiveness at the firm-level. Schumpeter initially identified innovation as a dynamic process of "creative destruction" supporting economic progress, later he extended this concept to firm-level "creative accumulation" of non-transferable knowledge in specific technological areas and markets as so-called "engines" for economic growth (Schumpter J. , 1912) (Schumpter, 1942).

In the knowledge era, the paradigm of defining resources, the constituents of production capacity shifts from land, labor, and capital being the main factors of production economy, to human capital (HC), structural capital (SC), and relational capital (RC). This is a very significant shift for developing nations since developing nations are mostly attributed to having mostly primitive levels of capital, therefore lacking infrastructure.

Establishing a national strategy for innovation is one thing; implementation is another matter. Such approaches in policy execution are looming in the policy orchestration of no other than Presidents Obama's the latest published innovation Strategy for American innovation released in February 2011 (Hemphill, 2013). The strategy considers the mechanism in funding Innovation and R&D efforts and an introduction of 100 Billion USD to cover the next 10 years of Scientific R&D and Innovation. Such funding efforts in policy execution are what this paper tries to investigate, the parametrization of the policy physical elements.

The framing of policies for innovation operates in a complex economic medium, dynamic and uncertain environment, where government action will not always get it right. A commitment to monitoring and evaluation of policies, and to learning from experience and adjusting policies over time, can help ensure that government action is efficient and reaches its objectives at the least possible cost (Hemphill, 2013). The 05/11/1976 Public law 94-282 of the United States, see (Appendix 1); however, induces national demand for an innovation economy; this initiative was inducted into our model to replicate the demand setting and its effect on brain drain and overall economic growth and impact. As this policy is the engine behind all the momentum in public funding in the United States, A replication of such Demand Building Policy and the size required based on a special economic scale was induced as a parameter input that would replicate a percentage of GDP as New Investments in R&D. Such policy induces an increased demand for High-Skilled Labor only in comparison with regular GDP Growth, therefore the immigration effect was considered as the economy of scale varies between the leading economies and the developing ones, the model, however, considers parameters that perhaps could build momentum for growth in trailing developing economies.

Migration and Development

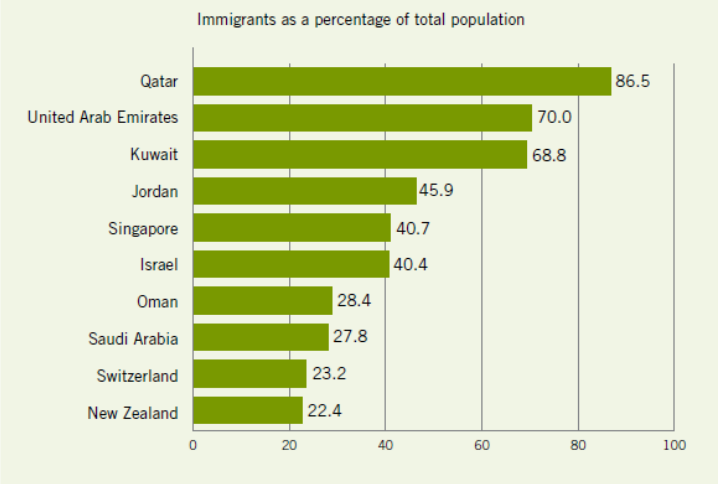
Migration Trends

Labor migration has existed throughout time and in all regions of the world. The search for more favorable job opportunities continues to be a major motivation behind migration and explains why labor migrants constitute an important share of international and internal migration stocks' in today economy. Aside from labor, other reasons for migration include conflicts, wars, and political persecution, as well as family reunification, educational opportunities, and climate change. Looking forward, projections indicate that, as a result of uneven demographic developments and large global Labour market disparities, the supply and demand for labor migrants could continue to rise, contributing to increased migration flows. Such labor flows have induced gains and losses that have not been equally spread between and within countries, fueling a controversial debate over the development impact of labor migration and the type of policies that States should pursue (Casez & Veck, 2013).

The effects unveiled in several papers include the loss in human capital or "brain drain" and some adverse effects of remittances on growth. By contrast, other studies totally support the overall idea of a migration-induced brain gain and find positive direct or indirect effects in terms of wages, remittances, and incentives to invest in schooling and health, poverty reduction, growth, innovation and trade flows. Ultimately, an important conclusion regarding the development impact of migration in host economies is that the migration effects depend above all on how the immigrants' skills compare to the natives' in the host region. There are both winners and losers; increased migration would normally negatively affect the wages of those workers who are close substitutes for immigrants, such as low-skilled native workers or previous immigrants.

In today's global approach to competition, the facet of even negative effects on migration has evolved into positive effects; it has controlled wages inflation in some countries, fulfilled a gap in labor demographic and provided a skill set level for others.

Stocks inflow of labor migration is not only a superficial phenomenon as perceived in some economies. Labor migration may constitute the demographic majority in some nations; which makes labor migration a key constituent in the human capital composition.



Source: United Nations, 2009.

1 Immigration Snapshot

Such demographic influence may raise a key question, Can Brain Gain alone influence economic development in capital rich states?

A comprehensive investigation conducted by the International Labor Organization Indicates key insights on the issue of labor migration; provided by the existing literature (Casez & Veck, 2013):

- Geographical disparities in economic opportunities and migration costs are the key drivers of labor flows. Second, studies that investigate the migration impact in sending regions reveal different effects of migration but do not supply conclusive analyses.
- Negative effects exposed in several papers include the loss of human capital or brain drain and certain adverse effects of remittances on growth.
- By contrast, other studies support the overall idea of a migration-induced brain gain and find positive direct or indirect effects in terms of wages, incentives to invest in schooling and health, poverty reduction, growth, innovation and trade flows.
- Finally, an important conclusion about the development impact of migration in host economies is that it results in both winners and losers. Ultimately, migration effects hinge crucially on how the skills of immigrants compare with those of the natives in the host region and whether labor flows are comprised of legal or irregular immigrants.

Yet there is another picture for labor migration, as observed by another ILO study, which indicates that the net inflow of skilled labor to the UK is Negative for the durations leading to 1984; Which means even when accounting for immigration to the UK, the number of UK skilled labor migrating away from the UK exceeded the figures of skilled laborers introduced to the UK market, such phenomena demonstrates a leading emerging behavior for developing countries dealing with new requirements of agility of the 'New Economy'. The figures were then reversed to demonstrate positive net inflow for years subsequent to 1985 (Findlay, 2001). Another significant statistic from the same study indicates that the number of US was equivalent to the number of Indian immigrant Immigrants to the UK, for the same period. Such changes in trends signify yet another characteristic for immigration, in which Immigration is not just limited to a unidirectional flow mechanism from developing to developed countries[3].

Migration & Brain Drain

Immigration Policy then becomes an instrumental policy in Human Capital Supply and Control. To that end, this paper will consider (Abdelbaki, 2009) main findings, as very little literature is scoped on the expelling economies' impact and implications; this paper will consider the economic losses as a behavior between the agents the Human Capital and the Expelling Economy's country. In his findings Abdelbaki identifies the following losses resulting from labor immigration as prescribed by (Borjas, 1995):

1- External Effects of Brain Drain of Labor: As the supply of skilled labor is reduced by the departing migrating skilled labor, the wages is then increased. In addition, there is an impact of productivity loss as the replacing skilled labor has not enough experience to better utilize the remaining unskilled labor, such activity results in a productivity loss. Such productivity loss is estimated could not be estimated, hence it was left as a variable to be modeled with a parameter between 1-20%.

2- Opportunity Cost Loss of Educational and Healthcare Costs: As immigrating labor will be exiting the economy all funds spent on healthcare and education. Since our paper is scoped to investigate the transient economy, such costs would be ignored as they are considered as overheads, since the transient economies do not invest in both education and health such costs would be ignored as the fees are picked up by the replacing immigrant.

3- Opportunity Cost Loss Costs in National Revenues:
    a. As migrating labor will stop any revenues to expelling countries economy in term of income taxes or/and national fees. Since the transient economies do not invest in both education and health such costs would be ignored as the fees are picked up by the replacing immigrant.
    b. A GDP Wealth Index was created as a cumulative sum of High-skilled labor Income, this is especially the case for high-skilled labor influence expansion of GDP through growth,

[3] This Bi-directional flow was apparent in the Simulation model as sky-country immigration was active and in some cases exceeded the number of skilled immigrant's figures native to the developing nations; this was the case until the GDP figures of the developing nation were ramped-up and became significantly higher than other economies. See Section 8 Model Natural Tendencies.

and also through their impact on innovation by creating and supporting Intellectual capital, and Relational Capital.

4- Losses of national scientists as skilled labor and scientists are the next forming of batch national researchers. An applied study demonstrated that 10% induction of immigrant skilled workers increased patents by 1.3% (Abdelbaki, 2009). Hence a negative Impact on innovation, technical and scientific research. This paper will consider the nation accumulated income of highly skilled labor multiplied by 0.0013 as an index for Innovation wealth.

Migration & Brain Gain

Brain Gain, a phenomenon even while positive in nature may be signaling an alternative dynamics or issue, The upsurge of skilled migration to the UK has not only involved workers in the 'new economy', but also professionals in the health and education sectors. This flow may be of greater concern, coming closer to what was in the past termed the 'brain drain'. While short run shortages of teachers or nurses may legitimately be satisfied by encouraging skilled immigration, the long-run shortfall in investment in training enough British-born doctors in the UK is problematic (Findlay, 2001). The same study also indicates a rise of 8% (from 22% to 30%) of professional staff in the years 1992 to 2000; this demonstrates also the growing importance of this socioeconomic group in developing nations regardless of whether the skillset is available or not. The report also emphasizes the need to improve salaries and career structures as well as efforts to encourage British skilled working overseas in skilled sectors to return to the UK, and considers such policies as appropriate management strategies to facing challenges in national skillset gaps.

In a relevant study performed by (Chellaraj, Maskus, & Mattoo, 2005) for the World Bank, the study Computed at sample means, a 10 percent rise in the ratio of foreign graduate students to total graduate students would imply an increase in later applications of 6,636 (or around 4.7 percent of the mean total applications of 141,092). Thus, we compute a marginal impact on another foreign graduate student to be around 0.6 patent applications in the economy as a whole; in addition, a ten percent rise in the six-year cumulated number of skilled immigrants would increase later patent applications by 1,037 (0.7 percent of sample mean), university grants by 12 (1.1 percent) and other institution grants by 814 (0.9 percent). The authors also suggested that countries such as the United States, Australia, Singapore, and more recently, the People's Republic of China, which have been relatively open to foreign talent, have experienced faster rates of economic growth than such countries as Germany, Japan, and Korea, where opposition to any form of foreign talent is significant. Thus, it seems plausible from this experience that a relatively open-door skilled immigration policy could play an important role in innovation and follow-on growth.

Structural Composition & Rigidity

Market Structural Conditions

Both Taiwan and Singapore are both relatively small countries that have transformed into successful, competitive economies and leaders in high-tech industries. National innovation systems are important in their development of a country's economic performance. In a study that explores the practice of the

innovation policies of Taiwan and Singapore (Yang, Lin, & Lin, 2014), and focuses on the supply side, environment side and demand side. In a comparative analysis of innovation performance between these two countries, Taiwanese public institutes take an active role in innovation/R&D and focus their policies on specific industries, a top-down approach, similar in principle to the US Policy, while the Singapore Government promotes innovation by public enterprises establishments. Regardless of approach; in the context of agent-based modeling, it was imperative however to identify an exogenous factor that identifies the: The Approach Influencing Factors; if such factors exist in the modeled economies; and to extend a bridge between the structural conditions and model. In an effort to create a symbolic multiplier caused by the market structural conditions and the innovation production function.

In the same study the market structural conditions were identified by three main types of policies, these types facilitate the innovation process, Supply Side Policies, Environmental Side, and finally Demand Side Policies. Such policies influence the economies in multitudes in ways:

In environmental-side policy approach, Singapore has promoted a significantly higher competitive and wider ranging benefits package, while Taiwan has established science parks and clusters that provide financial and tax holidays to specific industries. The most important direct subsidies in Taiwan are in the form of tax incentives. In Singapore, the effects of environmental side policy can be found in large FDI and specific grants, as well as tax holidays toward certain industry and innovation activities. As a result of efficiency and openness, Singapore has benefited from the presence of foreign MNCs, which bring in capital, technology, management know-how, and access to world export markets. Singapore also works with like-minded countries within international and regional organizations to encourage free trade.

The Taiwanese government has emphasized the use of government procurement and industrial cooperation policies to acquire advanced technologies, by utilizing the demand-side policy, such as aerospace technology, military technology, transportation technology, etc., which established the foundation of the high-tech industry in Taiwan (Industrial Technology Research Institute, 2005). It's worth noting that trade shows have also been of importance in bringing together key customers and manufacturers. The demand- side policy for Taiwan is mainly from the domestic market, whereas Singapore benefits more from regional and global integration See (Appendix 2) for Innovation Paradigm Policy. See (Appendix 3) for Innovation Policy for Developing Taiwan's Competitive Advantages Market Dimension

In a very delightful paper about Innovation (MarburgerIII, Dimensions of innovation in a technology-intensive economy, 2011), a separation between the terms and concepts is portrayed in trying to define Innovation. Marburger tries to draw a fine line between the innovation as a concept, and the type of innovation that we seek in trying to employ for growth. He also provides many innovations examples that were conceived from the scientific world that while correct, solid and self-proving in terms of ingeniosity, and scientific value, and then compares them to mechanical innovations conceived in market-driven environments, in the early stages and then later stages of industrial revolution, by not so much of scientific origins; and how such innovations helped provide to seed growth on exponential levels. He utilizes the World Wide Web for example as a business necessity, for communication for CERN, and how later, the WWW, created not just growth but the entire dimension of new economies.

A Booze and Hamilton Study in Innovation also considers such tales from history to illustrate components of the complex innovation ecology that are familiar to us today: an effective legal regime of intellectual property protection, an immigration policy that welcomes skilled workers, availability of investment capital, attention to the organization and management of work, and the prospect of profit from one's ingenuity. A distinction is made between Innovation as a science, policy, or/and outcome of innovation wealth without direction, a scalar that may not feed the growth engine. The authors prescribe innovation policies as an entity that is not exactly science policies, nor are they entirely technology policies. They are innovation policies, that were clearly important factors in the early lead established by both America and Great Britain in the industrialization of the nations that dominated global trade and manufacturing by the end of the nineteenth century. Similarly to that era, inspiring economies must establish

In both Booze's and the Marburger's studies, a conceptualization of forces seeding the innovation vector from a term of needs perspective of both environmental elements and already available structure in addition to a profitable base perspective that may then capture the output of innovation to capitalize on it. This is especially significant in terms of defining the required dimensions of innovative ecology pursued by policy.

If such direction is inter-related and should be market driven, then the existing economic space becomes the direction in defining Innovation. Some may argue that such paradigm of thought does not fit success stories in the Asian narrative of the Singaporean and Taiwanese scripts, but I argue, that the innovation outcome perceived was not in innovation as a force, but as a result of innovative planning; strategizing in national placement of either countries in a global financial space for Singapore or a Regional Manufacturing space for Taiwan, which in concept a very different paradigm of what is thought by Innovation Policy. Yet both the Singaporean and Taiwanese were successful in later adopting the types of policy suitable in further structuring and building additional momentum in their national innovation strategies.

Market Flex

It is long believed that the extent of a flexible labor market in Europe contributes to long-term competitiveness (CT-2001-00093 & Tsipouri, 2007). Yet Market Flex is too complex to be covered by a single term since the policy mix, discretionary powers of various actors and the potential effects of effective intervention differ greatly. In the same report key identities are unraveled,

The term "flexibility" has been used in so many different ways in the kindred fields of labor economics, industrial sociology, and political economy that it is very difficult to agree on its precise content and connotations. It is imperative to distinguish between "tactical" flexibility – the ability of a single-product firm to adjust output to exogenous shocks at relatively low costs – and "Operational" flexibility, as the ability of a firm to switch quickly between products was only the beginning of the debate.

Yet for developing nations, pressures for labor flexibility in medium that allows for immigration, and vast fluctuations in a the gross domestic product, attributed to the scale of economy, minute diversity level

of national income, and the fact that the working element of economy is imported, going through a cycle of peaks to correct for national unemployment levels, such trends in migration causes shocks that may amplify the issue altogether, requiring a planned demand policy that is long term. Yet such phenomenon was initialized in the model to demonstrate the need and effect for such relation as an emerged behavior of the entire system.

Economic Complexity

The overall wealth of knowledge that is required to make a product can vary enormously from one good to the next (Hausmann, C. Hidalgo, M. Coscia, & Chung, 2011). Yet to add to the complexity prescribed in this section, we may not be able to forecast or anticipate the probability of success in creating all products, as products vary in the type of knowledge they require. The accumulation of knowledge wealth required in planting bananas may be equivalent to the knowledge required in farming fish, yet the people involved in fish farming will have difficulties when planting bananas. Therefore a product space becomes the direction to the scalar entity of the accumulated wealth of knowledge. Just as nations differ in the amount of productive knowledge they hold, so do products, themselves. Most modern products require more knowledge than what a single person can hold. Every and even the simplest of products rely on others, and their individual know-how about battery technology, liquid crystals, microprocessor design, software development, metallurgy, milling, lean manufacturing and human resource management, among many other skills. That is why the average worker in a rich country works in a firm that is much larger and more connected than firms in poor countries. For a society to operate at a high level of total productive knowledge, individuals must know different things. The diversity of productive knowledge, however, is not enough. In order to put knowledge into productive use, societies need to reassemble these distributed bits through teams, organizations, and markets. Such indicator to the knowledge sphere as a quantity and direction is perhaps best demonstrated in the economic complexity index. The ECI indicator demonstrates a cumulative index that integrates the varied number of products, levels of complexity to produce and product space the product to serve. Such Index produces an indicator to the overall agent's level of the propensity in the production cycle and in turn an elemental and very important aspect of the overall economic production functions, which induces economic growth by time.

Product Space

The physical dimension of product space is derived from the Economic Complexity Section above, the product space when defined in a suitable manner that compliments the actual capital and constituents of the economy in question, allows subsequent strategies to capitalize on the existing factors in the national envelope. Such definition is crucial in identifying the path of least resistance; minimizing transformational periods of time required, and overall capitalizing on the existing factors allowing the nation to enlist the factors already owned to optimum use, improving the competitive advantage.

National Personal Income

An IMF publication discussing facets of Human Capital Issues faced by developing nations (Khan, 2011), identifies, Initial capital being a major hurdle, overall skills, rural exclusion, and unstructured markets being the major issues for development. It is rather intuitive, that if poverty is a national problem, then

poverty will further complicate all the issues mentioned above. One proposal of the report is to transform the supply driven the economy into a demand driven economy. This is a rather important aspect of innovation architecting in the national persona. The demand driven economy has to be established based on the national product space and also the present economic complexity achieved.

National Social Unemployment Policies

As the unemployment economic behavior is relevant to national social benefits (Huizen & Plantenga, 2003), the model ignores such behavior yet it was constantly apparent that such relation has significant influence on the model, and must be integrated in the model for improved results; as such factor ultimately influences GDP efficiency in providing expansion forces, It is was therefore estimated that such policy are considered main attractors that may influence model results in GDP Multiplier for new jobs; National Natural Level of Unemployment, and the resultant GDP Growth rate affected by both attractors. Hence it is envisaged that the function of national social benefits for unemployment shall affect two variables already integrated into the model:

- GDP Multiplier for new jobs;
- National Natural Level of Unemployment

These two factors were considered exogenous, for the purpose of this investigation. The ECI integration was deemed as sufficient replacement.

National Economic Complexity and GDP to Employment Relation

As the economic complexity is regarded an economic environmental setter in terms of National Economic Structure (Ferrarini & Scaramozzino, 2013), and the overall economic efficiency due to specialization, in terms of overall behavior; such overall complexity is deemed relevant to economic growth setter function, while the model does not ignore such behavior, it sets arbitrary figures, yet it was constantly apparent that such relation has significant influence on the model, and must be integrated in the model for improved results; as such factor ultimately influences GDP efficiency in providing expansion economic forces, It is was therefore estimated that such linear relations, could significantly influence the resultant GDP Growth rate affected by the attractors proposed. Hence it is envisaged that such future integration of national Economic Complexity and relation to GDP_New_Job_Multiplier shall significantly improve the model. The influenced relational already integrated into the model, but deemed relevant for integration:

- GDP Job Multiplier;
- GDP Growth Rate;

National Preparedness Index for Innovation

Such tales from history discussed in the market Dimension Section, that illustrate components of the complex innovation ecology that are familiar to us today: an effective legal regime of intellectual property protection, an immigration policy that welcomes skilled workers, availability of investment

capital, attention to the organization and management of work, and the prospect of profit from one's ingenuity. These are not exactly science policies, and they are not entirely technology policies. They are innovation policies, and they were clearly important factors in the early lead established by both America and Great Britain in the industrialization of the nations that dominated global trade and manufacturing by the end of the nineteenth century (MarburgerIII, Dimensions of innovation in a technology-intensive economy, 2011).

A need for an inclusive index was deemed necessary for modeling purposes, the rationale is if a country to sustainably acquire and accumulate Innovation wealth, National Income, GDP, and Economic Complexity independently, give an indicator of the dynamics emerging from the interactions of individual factors that produce a market efficiency indication to the innovation wealth creation dynamics. To that end, an Index was deemed necessary that integrated all elements demonstrating economic structural descriptive notions of the dynamics of the nation in question. Such Index does not exist hence an exogenous substitute was identified for utilization, economic growth scale for developing nations, yet when initially utilized, a problem was faced, in that statistics for developing nation that had complete dependence on natural resources export demonstrated a high growth rate without and production increases in actual economic output. The global landscape for economic growth that results shows the greatest potential for rapid growth in South Asia and East Africa. Conversely, oil economies and other commodity-driven economies face the slowest growth outlook (McKenney, 2015).To that effect, inclined to utilize the economic complexity in relation to the GDP growth phenomena, an indicator was generated utilizing both, National Preparedness for Innovation (NIP)=GDP Growth *(1+ ECI Growth).

Agent-Based Model components from an Innovation Growth and Immigration Policy perspective

Agent-Based Modeling Span Issue

It is proposed that complexity mythologies combined with traditional qualitative and quantitative methods can bring to light the clockwork of the elusive black box of complex systems. Recent studies suggest that it would be appropriate to use complexity based tools as an extension of exploratory analysis. In our phenomena of Innovation conceptualization for an Agent-Based model, approach utilization was continuously faced, is the conceptualization of the model and its extension span; as while modeling the researcher tends to be attracted into creating a full-blown general equilibrium model every step of the modeling. This tendency was then overcome by adopting Geyer and Cairney tier model conceptualization approach, which was deemed most appropriate in identifying a bridge between the phenomena layering approach utilized by the four layer framework of Williamson (1998) and the model elements in question. The layers proposed in four layer framework will constitute the variable space, and also draw the links between the attributes.

Innovation Model Creation Methodology

The Methodology followed in this research to gain insights into the innovation system, is to conceptualize the different layers that make up the hierarchy of the phenomena's physical space. In

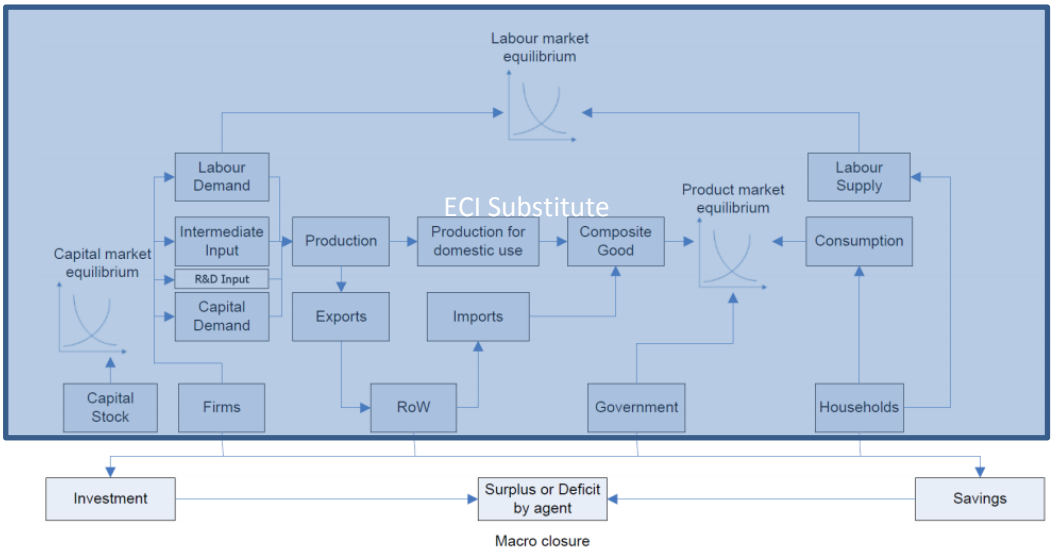
simplifying the phenomena system we gain major advantages; such as identifying exogenous factors growing or decaying at their own separate rates, eliminating the need to modeling correlated relations that cause simplification of the programming of the model, which in turn may become a constraint after some level of complexity. The four layer framework of Williamson (1998) is an approach to social and institutional arrangements in an integrated fashion, in this paper the economic arrangement was added. Like in complex systems theory (see e.g. Holling (2001) on the concept of 'panarchy'), each level operates at its own pace, protected from above by slower, larger levels but invigorated from below by faster, smaller cycles. Thus a multi-layer system can be described that shows both bottom-up and top-down causation. The following framework was prepared from the overall literature review conducted above.

Layer	Arrangement
Layer 1	Innovation Wealth Phenomena
Layer 2	Institutional environment
Layer 3	Economic Surplus/Deficit
Layer 4	Governance and Policy
Layer 5	National Production Attributes and Behavior
Layer 6	Individual Attributes and Behavior

Table 1 Model Layering for Causation

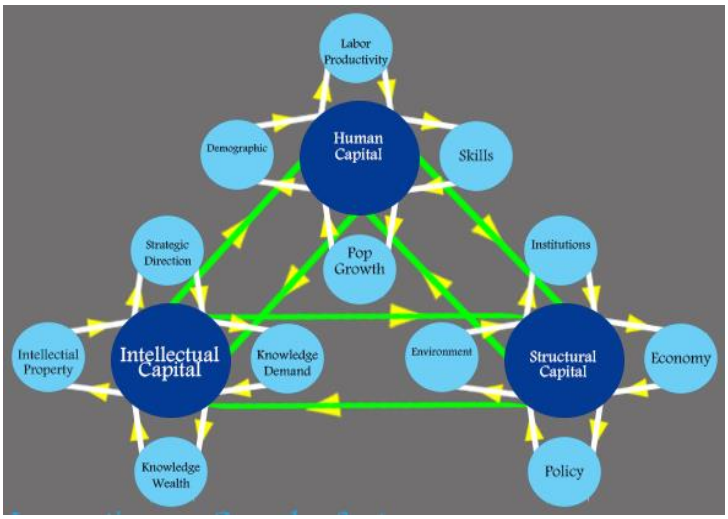
In layer 1 Innovation is a phenomenon that is a result of the Institutional environment, Innovation is a phenomenon that is a result of the Individual environment, and Innovation is a phenomenon that is a result of the Economic environment. Hence, and subsequently, Innovation is a phenomenon that is a result of the policy environment.

After identifying the layers of hierarchal phenomena in the physical space for Innovation, we then utilize The Kauffman model (Kauffman, 2008) as a simple representation of an economic network that can also be extended to illustrate a complex socio-technical system. Kauffman's model was originally formulated to show how future wealth would evolve in an economy. We have chosen this model for its simplicity in demonstrating how the two institutional frameworks can be applied to agent-based models of innovation systems. The basic model consists of a set of binary strings which represent resources and a grammar table that can convert these strings to other forms. For example, if we have '10011' and a conversion rule in the grammar table is: '10 to 111' then the string would be changed to '111101' using the conversion rule in the grammar table. In (Kauffman, 2008), Kauffman explains how these simple concepts can represent an evolving economy. The link between the basic terms used in the model and that of the real world are presented in (table 1). From this point, we will use the equivalent names in (table 1) when discussing the model.

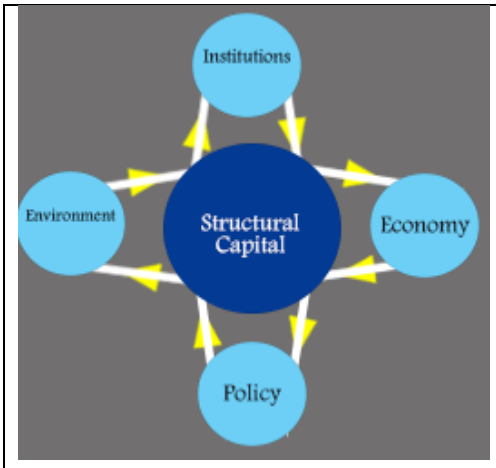
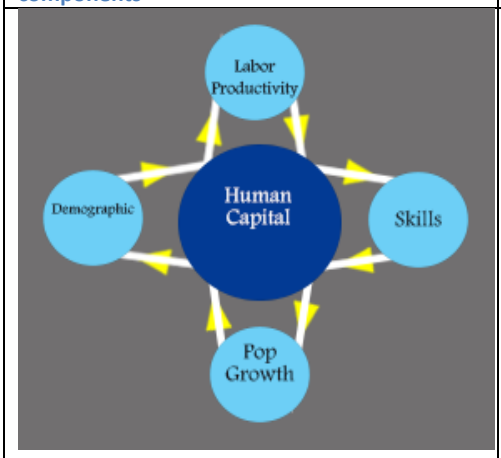
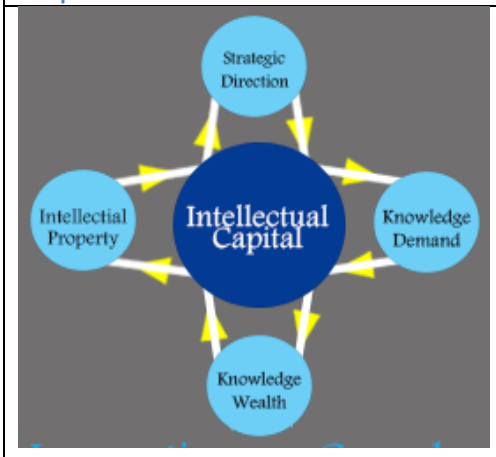


2 Substitution Economic Factor- Source from (Comite & Kancs, 2015)

This paper Considered innovating an equation for GDP growth that would be influenced by population, economic complexity, base salary structure and innovation wealth. A deterministic approach that is exogenous. Such simplification would then the entire model to consider the Economic growth that is influencing innovation as a subset of the economy but also is influenced by the innovation wealth being created. Based on the Building a System Dynamics Model Part 1: Conceptualization approach in (Appendix 4, section 1), the following is a brief interaction description of the Agent-Based Model, deemed necessary for the Policy Formulation exercise under question. The table below identifies the subset description of the ABM factors consideration, the relations provided were produced by the author of this paper, the methodology utilized was built utilizing the methodology from (Albin, 1997). From the literature review, the proposed interactions were concluded.



3 Innovation Factors Interaction HC, IC, SC; B. Ourabi

 4 Innovation SC, Interaction with sub-components	Institution, Environment, and Policy are correlated with Economic Complexity Index based on the literature review, such factors were considered exogenous and correlated to Economic Complexity Index, and therefore a multiplier was set to correlate with the ECI. The economy was extended by influenced demand, innovation and immigration, therefore, was set as an endogenous factor.
 5 Innovation HC, Interaction with sub-components	Labor Productivity; Skills are correlated with Economic Complexity Index based on the literature review, such factors were considered exogenous and correlated to Economic Complexity Index, and therefore a multiplier was set to correlate with the ECI. Population growth was eliminated as such factor derives change on the very extended long-term, out of the scope of this model. Demographics and labor matching were substituted by immigration, therefore was set as an endogenous factor.
 6 Innovation IC, Interaction with sub-components	Strategic Direction; while a competitive driver yet out of the scope of this research, was excluded, but deemed very imperative for future studies. While Knowledge wealth and demand are correlated with Economic Complexity Index based on the literature review, such factors were considered exogenous and correlated to Economic Complexity Index; these were then overturned to endogenous as our proposed policy review aims to examine how policy may affect the overall intellectual capital and innovation, thus was substituted by immigration and demand influence. Intellectual property laws were correlated with Economic Complexity Index based on the literature review, therefore removed and substituted by ECI also.

Model Boundary

From the Innovation Factors Interaction model above (figure 9); an initial components list is generated; this list will provide the Input and interaction dynamics of the proposed model.

Initial Components List -Innovation	
Human Capital – Wealth	Structural Capital – Institution
Human Capital – Skills	Structural Capital – Policy
Human Capital – Labor Productivity	Intellectual Capital – Wealth
Human Capital – Demographics	Intellectual Capital – Knowledge Wealth
Human Capital – Population Growth	Intellectual Capital – Intellectual Property Rights
Structural Capital –Wealth	Intellectual Capital – Knowledge Demand
Structural Capital – Economy	Intellectual Capital – Strategic Direction
Structural Capital – Environment	

Table 2 Innovation Initial Components List

The initial components list is then divided up and a boundary list is formed.

Endogenous Components-Innovation	Exogenous Components-Innovation
Human Capital – Wealth	Population Growth
Human Capital – Skills	Structural Capital – Economy
Structural Capital –Wealth	Human Capital – Labor Productivity
Structural Capital – Policy	Human Capital – Demographics
Intellectual Capital – Wealth	Human Capital – Population Growth
Intellectual Capital – Knowledge Demand "Wage Setting"	Structural Capital – Environment
Intellectual Capital – Knowledge Wealth	Structural Capital – Institution
	Intellectual Capital – Intellectual Property Rights
	Intellectual Capital – Strategic Direction

Table 3 Model Boundary List

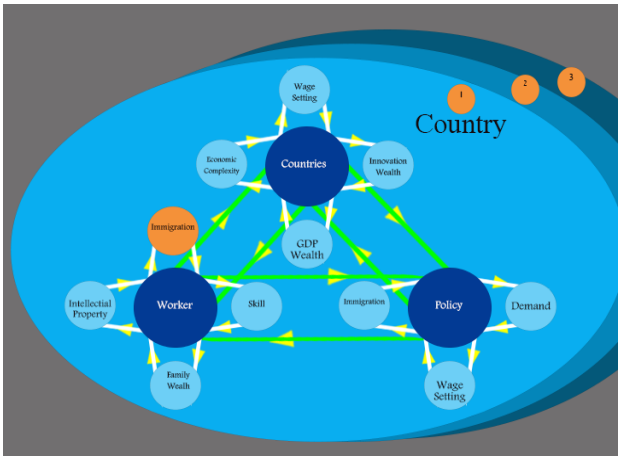
Because the purpose of building the model is to trace the natural path of innovation in a country, given a specific policy that influences endogenous items the base model should include policy. Induced policy would mask the natural course of innovation and demonstrate the emerging behavior of innovation.

The relevant innovation in a country is derived from the actual GDP growth and accumulation. Both the wealth of structural capital and human capital are thus to be excluded from the model boundary, though they exist on the initial components list. The system description states that innovation of the population can be taken as a constant ratio of GDP, thereby making it an exogenous component. Carrying the knowledge makes no difference to the immigrants so the immigration fractions for all people (Highly skilled and otherwise) are constant exogenous components of the system. The immigration fraction for skilled people is also an exogenously measured constant fraction. The dynamic components of greatest interest when charting the course of innovation are the number of high-skilled labor and number of unemployment, and the immigration rates. Other important components are the number of infectious mosquitoes, the number of infectious humans, and the number of incubating

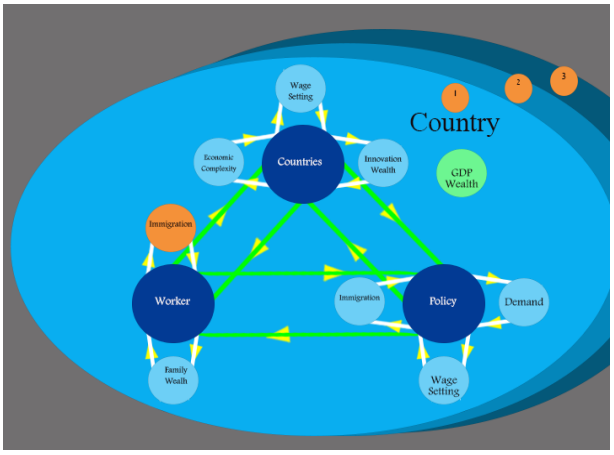
humans. All of the above dynamic variables are endogenous components of the system. Because the model system deals with a short time horizon, the birth fraction and birth rate for people will not affect the dynamics of innovation migration. Because all humans living in the area can be divided into one of the human population stocks (High-Skilled, Medium Skills, Low Skills, remaining, migrating returning, and migrating staying), there is no need to create an additional human population stock in the model.

Since the perspective of the model is agent based, we initialize all the endogenous components from an actor perspective's; in this case people and countries. The policy will be included as an exogenous factor.

Since we are comparing innovation from a competitive perspective, and considering how innovation is flowing from one country to another; a three-country model was utilized to model the transient economy of the GCC demonstrated in this model by Qatar.



7 Innovation Factors Interaction HC, IC, SC; Competing Economies



8 ABM Model Factor Interactions Exogenous and Endogenous

The Base Model

An ABM is a type of computational model that is used to study complex systems by exploring how individual elements (agents) of a system behave as a function of individual characteristics and interactions with each other and the environment. Each agent interacts with other agents based on a set of rules and within an environment specified by the modeler, which leads to a set of specific outcomes, some of which may be unexpected. Such approach can be used to explore the potential impact of policies and interventions in dynamic social and physical environments, ABMs may be a useful tool to aid in decision making by policy makers (Wallace, Geller, & Ogawa, 2015).

A base model Created by Matteo Assandri, and Noemi Oggero [4]Simulating a job market with migration (Assandri & Oggero, 2014) and different skill levels were added and utilized as the immigration engine for the model. In the base model, three countries were designated with different unemployment levels and salaries structure for three skill sets, low, medium, and high skill level workers. A migration function was also defined as three countries being of different distances from each other simulating different hardship to migration, also a cost function was introduced in the decision for the migration decision based on expected overall income of the family compared with native country, and this expected income was then corrected for by incurring a migration cost. The base model was affirmed to features the real job markets. Also, workers are bound by the family decision when they take the decision of migrating. There are also people that would not migrate if they were singles, but they do migrate to the whole family would be better off (tied movers) and others that cannot migrate even if their salary would be higher because the family is better off in the actual country (tied stayer). Secondly, if in the base model the wages differential is really high, workers are more likely to migrate since the increase in income is greater than the costs of migration. Moreover, the base model provided insight how being a member of a family helps in migrating when there are huge material costs to face and how the job market attracts foreign workers. Finally, in the charts that show the skills of the workforce, a demonstration of the effect those of high-skilled workers have on low-skilled ones. For more details on the base model see (Appendix 4).

The Modeling Approach and Objective of this paper

For our analysis, the economic influence immigration model was transformed to include economic indexes, sizes, and economic behaviors that exhibit relations, efficiencies and forces, in the real world economy; differences between developed, middle and low income developing countries was targeted in the modeling.

A review of multi-agent system models and policy and economics noted the obstacles to empirical agent parameterization and the lack of overall data at a suitable scale (Evans & Kelley, 2004). (Berger & Schreinemachers, 2011) In their paper, they induced data instruments to sample real populations and various techniques for injecting empirical information into a spatially explicit ABM. In this paper's efforts to utilizing multi-agent system models, a similar method of injecting empirical information was utilized.

[4] The Base Model is Immigration –Agent Based Model, this modal was influential in my model building exercise, as it included a complex immigration algorithm, The Model is a Masters Dissertation for the University of Torino, Italy.

Additions to the original model were modeled to exhibit the complex system in question:

- A GDP Starting Parameter for each Country
- A Population Starting Parameter for each Country
- A Population growth rate for each Country
- A demographic of Labor skill setting per country
- An income structure was initiated to demonstrate differences in compensations between skills and countries
- Innovation Wealth and GDP wealth variables were introduced to each country.
- An Economic Complexity Index for each country was initially Parametrized.
- A GDP Job Multiplier was Initialized based on Economic Complexity
- An Unemployment Variable was set for each skill set separately in each country
- An Overall Unemployment Variable was Integrated that captures Individual labor type unemployment to capture Overall economic status
- A GDP Natural Growth rate was introduced for each country
- An Overall GDP Wealth and Innovation Wealth Index for each country
- A minimum and maximum life expectancy was introduced to simulate random ages for each worker, as the innovation function is incremented with time; and

Finally added two charts that show the accumulated GDP with time and accumulated Innovation wealth with time as such wealth is a result of high-skilled workers. For more details on the model changes; see (Appendix 4), see (Appendix 4 Section 3) for Initial Conditions & Model Macro-Behavior and Model Description.

Model Validation

When considering the World Bank data for GNI per capita for the three pilot economies we have identified a similar pattern in the model.

Section 3 Model Experiments

Wage Setting

As concluded earlier, there is no robust empirical evidence that demonstrates increases in the minimum wage cause large disemployment effects; nor is it clear that the resulting wage gain among those who keep their jobs is large enough to increase the share of earnings going to low-wage workers in the covered sector. To that end, the model was set to variant initial conditions simulating wage setting (Minimum Wage Setting) for minimal skills employees in a state. For executing such policy setting, the minimum wage was calculated to being a percentage of Middle Skills Employment Compensation for a specific nation, Developing Labor supplier economy.

Permitted Immigration	Skill Level	Sky Country	Gray Country	Yellow Country
Yes	High	2	3	0
	Medium	2	3	0
	Low	2	3	0
Innovation		Becomes Second	Becomes First	Remains Third
Notable Initial Conditions:				
• **Base Price Differential 300% Higher in Gray country compared to Sky. In High Skill Only**				

Table 4 Wage Setting

Immigration-Setting- Permitted, not permitted (Wall Policy)

With Immigration permitted we have an emerging behavior conditions, that the base salary structure formed prioritizes high skilled, as in the gray country, remaining skills (Medium and Low) were higher than other two countries; this is a problem in forming competition between countries, see below table, also (Appendix 5).

Permitted Immigration	Skill Level	Sky Country	Gray Country	Yellow Country
Yes	High	3	2	0
	Medium	2	3	0
	Low	2	3	0
Innovation		Remains First	Remains Second	Remains Third
No	High	2	3	0
	Medium	2	3	0
	Low	2	3	0
Innovation		Declines to Second	Inclines to First	Remains Third
Notable Initial Conditions:				
• **Base Price Differential 50% Higher in Gray country compared to Sky.**				

Table 5 Immigration Permitted/Not Permitted Experiment

Knowledge Demand Induction

With Immigration permitted we have an emerging behavior conditions, that the base salary structure formed prioritizes high skilled, When Inducing Demand for Knowledge Jobs as where in Sky country, a pattern was replicated in leading in innovation, and appreciation in base salaries on all levels of skills, replicating the sky countries, also (Appendix 5) section 3.

Permitted Immigration	Skill Level	Sky Country	Gray Country	Yellow Country
Yes	High	2	3	0
	Medium	2	3	0
	Low	2	3	0
Innovation		Becomes Second	Becomes First	Remains Third
No	High	2	3	0
	Medium	2	3	0
	Low	2	3	0
Innovation		Declines to Second	Inclines to First	Remains Third
Notable Initial Conditions: • **Distance of countries between Gray and Yellow, 0** • **Base Price Differential 0**				

Table 6 Demand Knowledge Induction

Immigration Friction Reduction

Permitted Immigration	Skill Level	Sky Country	Gray Country	Yellow Country
Yes	High	2	3	0
	Medium	2	3	0
	Low	2	3	0
Innovation		Becomes Second	Becomes First	Remains Third
No	High	2	3	0
	Medium	2	3	0
	Low	2	3	0
Innovation		Declines to Second	Inclines to First	Remains Third
Notable Initial Conditions: • **Base Price Differential 50% Higher in Gray country compared to Sky.**				

Table 7 Immigration Friction Reduction

Immigration Expulsion Policy

Similar to the original model the expulsion element was considered by offering no incentives to minimize economic incentives to migrate, this was considered as an expulsive government behavior. Similar to the Original model setting Innovation lagged, and even worse the pricing emerged behavior offered no competitive advantage.

Table 8 Immigration Expulsion

Permitted Immigration	Skill Level	Sky Country Emerging Salaries Levels	Gray Country Emerging Salaries Levels	Yellow Country Emerging Salaries Levels
Yes	High	3	2	0
	Medium	3	2	0
	Low	3	2	0
Innovation		First	Second	Third
Notable Initial Conditions: • **Distance of countries the same** • **Base Price Differential 0** • **Economies Different** • **Economic Complexities Different** • **Worker Skills Demographics Different** • **Open (Job Global Competition)**				

Combinational Policy

Similar to the original model the expulsion element was considered by offering no incentives to minimize economic incentives to migrate, this was considered as an expulsive government behavior. Similar to the Original model setting Innovation lagged, and even worse the pricing emerged behavior offered no competitive advantage.

Permitted Immigration	Skill Level	Sky Country Emerging Salaries Levels	Gray Country Emerging Salaries Levels	Yellow Country Emerging Salaries Levels
Yes	High	3	3	0
	Medium	3	3	0
	Low	3	3	0
Innovation		First	First	Third
Notable Initial Conditions: • **Distance of Sky Yellow Increased** • Distance for Gray Yellow Decreased • Distance for Gray Sky Decreased • **Demand Knowledge Wage Setting at 300% of Sky**				

Table 9 Original Model With WorldBank Settings

Section 4 Discussion & Recommendations

Model Proposed Natural Tendencies & Findings

The next phase of the Asian market expansion, an Incremental statue of infrastructure concurrently taking place in most leading and lagging economies interim of policy initiation for the purpose of knowledge transitions is going to further increase the competing conditions for high-skilled labor, this competition will induce an inflation in overall labor costs.

Such labor costs increase will induce a competitive disadvantage with leading economies for the short run. Until a transitional improvement in innovation wealth is improved to exceed developing nation's level. Such time frame will be extended as lagging economies will face difficulties in structural rigidities, as they improve on industrial complexities and the buildup of national institutions and sizing up the demand market to facilitate the consumption of produced innovation hence creating economic surplus due to the innovation produced.

High skilled Labor concentration is apparently a leading attractor for innovation wealth and the growth rate required. Policy tools, in influencing labor migrational tendencies are an effective tool in addressing innovation wealth creation dilemma as a transitional tool until a more solid economy is formed.

Structural rigidities as demonstrated in economic complexities may be corrected for by High skilled Labor concentration and industrial concentration.

Model Influenced Proposed Innovation Strategy Development Policy

To expedite the cycle, a demand market creation for innovative wealth must be initiated to improve upon the growth rate.

Immigration friction reduction policy must be considered, as it is required for both short term and long term in the objective of innovation wealth creation. Yet such Immigration friction reduction approach shall be concentrated on high-skilled labor, for the interim period, as an all skill set Immigration friction reduction policy may also increase the wage setting for both middle and low skill sets wages without a significant return.

A multifaceted policy must be considered; as single policies alone were deemed not sufficient. Also, the phasing of each facet was deemed empirical as phasing of certain policies at the wrong time, was deemed counterintuitive.

For our transient economy example Qatar, Immigration policy followed by a wage-setting policy and finally followed by a demand influence policy, for high skilled labor was demonstrated suitable. Any of these policies in a different order provided no evidence in diverging gaps in innovation when compared with leading economies.

Finally, when considering innovation policies, wage level inflation must be considered as a main trigger and control parameter, in an effort to ensure global competitiveness.

n	Proposed Policy	High Skill Set Wages	Medium Skill Set Wages	Low Skill Set Wages	Time to Convergence in Economic Competition	GDP & Innovation	See Appendix 5
1	No Policy Change –Gray Immigration Expulsion	Exponentially Higher-Gray	Exponentially Higher-Gray	Exponentially Higher-Gray	Never	Sky Diverging	Section 1
2	Immigration Friction Induction	Marginally Higher-Gray	Marginally Higher-Gray	Medium Higher-Gray	Long Time	Gray Diverging	Section 2
~~**3**~~	~~Induced Demand~~	~~Exponentially Higher-Gray~~	~~Exponentially Higher-Gray~~	~~Exponentially Higher-Gray~~	~~Short Time~~	~~Gray Diverging~~	Section 3
4	~~Wage Setting~~	~~Exponentially Much Higher-Gray~~	~~Exponentially Much Higher-Gray~~	~~Exponentially Much Higher-Gray~~	~~Short Time~~	~~Gray Diverging~~	Section 4
~~**5**~~	~~Combinational Absolute (all Skills)~~	~~In Control~~	~~Exponentially Much Higher-Gray~~	~~Exponentially Much Higher-Gray~~	~~Short Time~~	~~Gray Diverging~~	Section 5
6	Combinational High Skill Only	In Control	In Control	In Control	Short Time	Gray Diverging	Section 6

Table 10 Simulation Model Innovation Policy Conclusion

Policy Options 3,4,5 were removed as the exponential higher wages behavior in especially the low skilled set group was considered a competitive disadvantage in the global economic race, therefore option 6 was introduced to maintain the status quote in open market condition that is currently exercised, in medium and low skill sets wage setting.

Model Future Considerations

The sharp growth rate in Innovation wealth creation is currently increasing the gap on an incremental rate, for developing nations, that in the future the difference will be hard to reduce such difference in gaps, due to scales.

It is proposed additional research in scales modeling is conducted to identify accurate parametrization deliverables for policy formulation.

For modeling purposes, a reoccurring question of innovation incremental growth rates in existing national product space and new product space would be invaluable.

Also for modeling purposes, a reoccurring question of whether innovation incremental growth rates in existing national product space did indeed improve competitive advantage, and on what scales.

Policy Brief -Final Remarks on Innovation, Economics, Immigration, Complexity Computation and Policy formulation.

Previously Economics was the political economy. According to classical economists, the science of economics has to steer real economies them towards desirable outcomes by control. If one considers the economic approach of mainstream (neoclassical) economists. There is a widespread and popular opinion, summarized by (Brock & Colander, 2000), that complex systems and its overall complexity don't add anything new to the toolbox of mainstream economic policy analysis. This approximation of the special envelope of economics needs substantial corrections; see also the reflections by (Blume & N.Durlauf, 2000). Best diagnosed by Prigogine, the complexity approach demonstrates that the age of certainty has eroded with the non-equilibrium revolution[5]. In considering the economy as an evolving (adaptive) system we have to admit that our understanding is limited: as there becomes no room for the Laplacian[6] demon in complexity, as classical mechanics is simply not evolutionary[7]. However, agents are still rational-oriented, in that they do what they can in order not to commit systematic errors (Lewontin & Levins, 2008). Since emergent facts are transient phenomena, policy recommendations, therefore, are less certain, and they should be institution dependent and historically oriented (Finch & Orillard, 2005) In particular, it has been emphasized that through complex systems can be either extremely fragile and/or turbulent (a slight modification in some minor detail brings macroscopic changes), or relatively robust and stable: in such a context, policy prescriptions ought to be case sensitive, considering all initial conditions and emerging behavior but utmost be time-phase oriented in considering at which time phase should a certain policy reside.

The trend changes in migration due to the 'new economy', especially in technological fields requiring a high skill set, are symptoms of an unprepared economy in dealing with resource preparedness and allocation mechanisms that are best suited for the national envelope as laid out in the Migration and Development (Section 2) in the Brain Gain sub-section. Yet such output is also the result of an interaction of environmental factors that are construed by a complex system of innovation these factors are:

1. Human Capital
2. Intellectual Capital
3. Structural Capital

[5] Non-Equilibrium Revolution: Initiated by concepts importance for non-equilibrium thermodynamics include time rate of dissipation of energy (Rayleigh 1873). Economic and biological systems, as open dissipative systems, need to extract low entropy from the environment to compensate for continuous dissipation. This process can be represented by lognormal processes, which in turn can be mapped into a thermodynamic equation. From here, the development of the concept, an analytic thermodynamic theory of economics, or the non-equilibrium revolution. Since a thermodynamic equation is of first order in temporal dimension, economic and biological systems as thermodynamic systems are intrinsically evolutionary.

[6] In the history of science, Laplace's demon was the first published articulation of causal or scientific determinism by Pierre-Simon Laplace in 1814. According to determinism, if someone (the Demon) knows the precise location and momentum of every atom in the universe, their past and future values for any given time are entailed; they can be calculated from the laws of classical mechanics.

[7] The main stream research in economics is pushing to evolutionary concepts in economics, as interactions between agents create emerging behavior, the concept of which this paper is about.

Current policies, including Immigration policy mainly, is influencing overall national capacity without considerations to the short run, or long-run shortages cause which is problematic as they are usually signaling for overall shortfalls in the national human capacity building required. Yet it seems plausible from this research findings, to support a relatively open-door high-skilled immigration policy; such policy could play an important role in facilitating innovation and follow-on growth while considering enabling policies such as wage setting and demand creation policies in certain order.

The ABM approach as a paradigm for Policy Analysis has uncovered through this work that:

- ABM is capable of demonstrating interaction levels amongst all agents, on a macroeconomic scale
- The combinational elements provided and then demonstrated equates to an immense amount of information creation. Such scale of Information combined with the initial conditions becomes a wealth of data; usually, developing countries lack for their policy formulation, hence shifting the formulation to such new paradigm may ultimately eliminate weaknesses usually attributed to developing environments. Such shift in paradigm is prescribed by this investigation as a new opportunity, the Agent-Based approach in specific.
- The Strategic Direction of Product Space specialization could enable colossal growth and provide a competitive advantage in Economic Complexity creation, especially due to Initial GDP Volume condition, between countries.

Finally, computational policy analysis identified:

- Many aspects on how ABM may aid in insight, and contribution to the field of policy formulation, especially in multifaceted policy creation and phasing
- Identifying strategic direction, while not modeled constantly surfaced as an empirical enabling factor in Economic Complexity, Maturity, and Creation.
- Developing nations shall consider structuring centers for computational analysis research; such centers would aid in Policy formulation, tuning, and time phase identification, a forecasting mechanism for policy effectiveness or/and success, and often missing element in execution of international world class policies; The paradigm shift utilized in such mechanism could also aid in scientific research contribution at a colossal scale, addressing the gaps thought after to fill in this Innovation policy, to begin with.
- While this study focused on demand and supply side factors, imperative additional work required on the environmental side factors (Structural Rigidity).
- Due to immigration and steep gaps in GDP and related initial conditions, Innovation policy must focus on global rather than just domestic and regional capacity.

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Appendix

Appendix 1 The US Innovation Policy

The US Innovation Policy

05/11/1976 Public law 94-282 (An Act to establish a science and technology policy for the United States, to provide for scientific and technological advice and assistance to the President, to provide a comprehensive survey of ways and means for improving the Federal effort in scientif, 1975-1976);

Title-1 Declares it to be the national policy that the Federal investment in science and technology must be addressed to the priority needs of the Nation, including:

(1) Promoting conservation and efficient utilization of natural and human resources;

(2) Protecting the oceans and coastal zones;

(3) Strengthening the economy and promoting full employment;

(4) Assuring adequate supplies of food, materials, and energy;

(5) Improving the quality of health care; and

(6) Improving the nation's housing, transportation, and communication systems.

Declares that the United States shall adhere to a national policy for science and technology which includes the following principles:

(1) the continuing development and implementation of a national strategy for determining and achieving the appropriate scope, level, direction, and extent of scientific and technological efforts based upon a continuous appraisal of the role of science and technology in achieving goals and formulating policies of the United States;

(2) the enlistment of science and technology to foster a healthy economy in which the directions of growth and innovation are compatible with the prudent and frugal use of resources and with the preservation of a benign environment; and

(3) the development and maintenance of a solid base for science and technology in the United States.

States the declaration of Congress that the Federal Government should maintain central policy-planning elements in the executive branch in mobilizing resources for essential science and technology programs, in securing appropriate funding for those programs, and to review systematically Federal science policy and programs and to recommend legislative amendments when needed.

States that, in order to expedite and facilitate the implementation of the policy enunciated in this Act, the following coordinate procedures are of paramount importance:

(1) Federal procurement policy should encourage the use of science and technology to foster frugal use of materials, energy, and appropriated funds; to assure quality environment, and to enhance product performance;

(2) Explicit criteria, including cost-effectiveness principles where feasible, should be developed to identify the kinds of science and technology programs that are appropriate for Federal funding support and to determine the extent of such support; and

(3) Federal promotion of science and technology should maximize the quality of research, the stability of scientific and technological institutions, and, for urgent tasks, timeliness of results.

Title-2 The Office of Science and Technology Policy= - Presidential Science and Technology Advisory Organization Act - Establishes in the Executive Office of the President the Office of Science and Technology Policy. Provides for the appointment of a Director, four Associate Directors, and other personnel.

Specifies the functions of the Office, including to:

(1) Advise the President of scientific and technological considerations involved in areas of national concern;

(2) evaluate the scale, quality, and effectiveness of the Federal effort in science and technology and advice on appropriate actions;

(3) Advise the President on scientific and technological considerations with regard to Federal budgets; and

(4) Assist the President in providing general leadership and coordination of the research and development programs of the Federal Government.

States that the Office shall serve as a source of scientific, engineering, and technological analysis and judgment for the President with respect to major policies, plans, and programs of the Federal Government.

Requires the Director to establish an Intergovernmental Science, Engineering, and Technology Advisory Panel to identify and define civilian problems at State, regional, and local levels which science, engineering, and technology may assist in resolving or ameliorating.

States that the Office shall prepare and annually update a five-year forecast which shall identify and describe situations and conditions which warrant special attention, involving current and emerging problems of national significance that are identified through scientific research, or in which scientific or technical considerations are of major significance.

Requires the Director to:

(1) Serve as Chairman of the Federal Coordinating Council for Science, Engineering, and Technology established under title IV;

(2) Serve as a member of the Domestic Council; and

(3) at the request of the National Security Council advise the Council in such matters concerning science and technology as relating to national security.

Directs the President to transmit an annual Science, Engineering, and Technology Report to the Congress, which shall be prepared by the Office.

Title-3 President's Committee on Science and Technology= - Requires the President to establish a President's Committee on Science and Technology.

Requires the Committee to survey, examine, and analyze the overall context of the Federal science, engineering, and technology effort including missions, goals, personnel, funding, organization, facilities, and activities; and to submit a report of its findings, conclusions, and recommendations to the President within two years of its activation.

Requires the President to transmit the report to Congress.

Terminates the Committee 90 days after submission of its report to the President.

Purpose of the National Scientific Subject R&D Strategic Plan

Through the analysis of the National Scientific Artificial Intelligence R&D Strategic Plan, published by the White House in 2016, the prioritization of the NTSC in identifying a strategic National Plan in a specific field of scientific inquiry was done to the following criteria:

- Identifying an emerging field of scientific inquiry, that plays a crucial role in impacting everyday lives

The purpose of the strategic plan is hence to answer a few questions usually associated with the newly identified field of scientific inquiry. The questions seek to identify to identify the ultimate direction and implications of these technologies by answering the following main questions:

1- What are the important scientific and technological gaps in current technologies related to the subject of scientific inquiry?
2- What would new subject -of scientific inquiry- advances provide positive, needed economic and societal impacts?
3- How can the -subject of scientific inquiry- technologies continue to be used safely and beneficially?
4- How can the -subject of scientific inquiry- systems be designed to align with ethical, legal, and societal principles?
5- What are the implications of these advancements for the - subject of scientific inquiry- R&D workforce?

Identifying the landscape for - subject of scientific inquiry- R&D

The landscape related to technology is becoming increasingly complex. While past and present investments by Government have led to groundbreaking approaches to the related field of scientific inquiry, other sectors may have also proved to become significant contributors to the field outside of government, including a wide range of industries and non-profit organizations.

This diversity of technological investment landscape raises major questions about the appropriate role of government investments in the development of the subject of scientific inquiry related technologies. Some questions arise due to this diversity:

1- What are the right priorities for governmental investments, especially regarding areas and timeframes where the industry is unlikely to invest?
2- Are there opportunities for industrial and international R&D collaborations that advance national priorities?
3- How may government conduct further coordination across the government so that these investments can achieve their full potential?
4- How may government engage a public dialogue on the subject of scientific inquiry, and help identify the challenges and opportunities the subject may entail.

The answers to the above questions would then aid in identifying the following:

1- Priorities that address strategic research goals, focus government investments on those areas in which industry is unlikely to invest,
2- Address the need to expand and sustain the pipeline of the subject of scientific inquiry R&D talent.

The desired outcome shall assist the government in identifying:

1- The impact of these technologies, and provide policymakers with the knowledge needed to address complex policy challenges related to the use of the subject of scientific inquiry.
2- Define a high-level framework that can be used to identify scientific and technological gaps related to the subject of scientific and
3- Track the Government R&D investments that are designed to fill those gaps. Hence the Strategic Plan identifies strategic priorities for both near-term and long-term support related to the subject of scientific inquiry that addresses important technical and societal challenges.

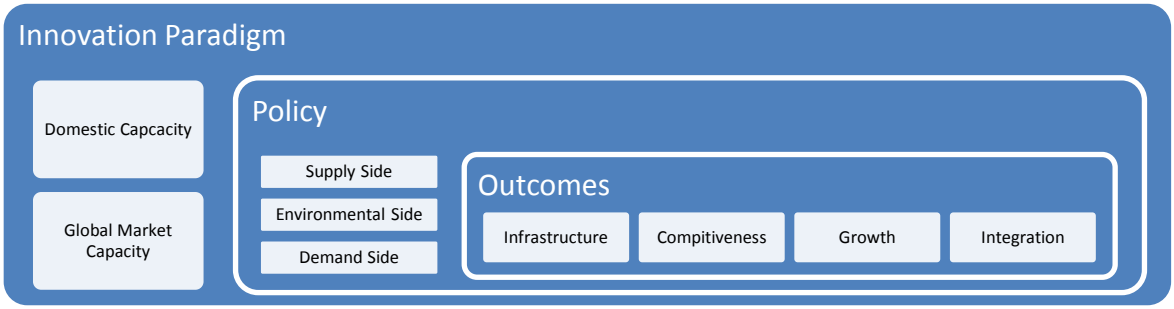
Note1: While the strategic plan shall not be entitled to set a research agenda; it sets objectives for the Executive Branch, within which agencies may pursue priorities consistent with their missions, capabilities, authorities, and budgets so that the overall research portfolio is consistent with the subject of scientific inquiry R&D Strategic Plan.

Note2: It is the role for the Economic Council to better associate the impacts related to the subject of scientific inquiry related Opportunities and Challenges.

In conclusion, the R&D Strategic Plan focuses on the R&D investments needed to help define and advance policies that ensure the responsible, safe, and beneficial use of the subject of scientific inquiry.

Appendix 2 Policy Factors –Innovation Paradigm

Innovation Paradigm Policy



9 Innovation Paradigm Outcomes

Appendix 3 Grouping of Innovation Policy

Adapted from Shyu & Chiu, Innovation Policy for Developing Taiwan's Competitive Advantages (2002), based on Rothwell and Zegveld (1981).

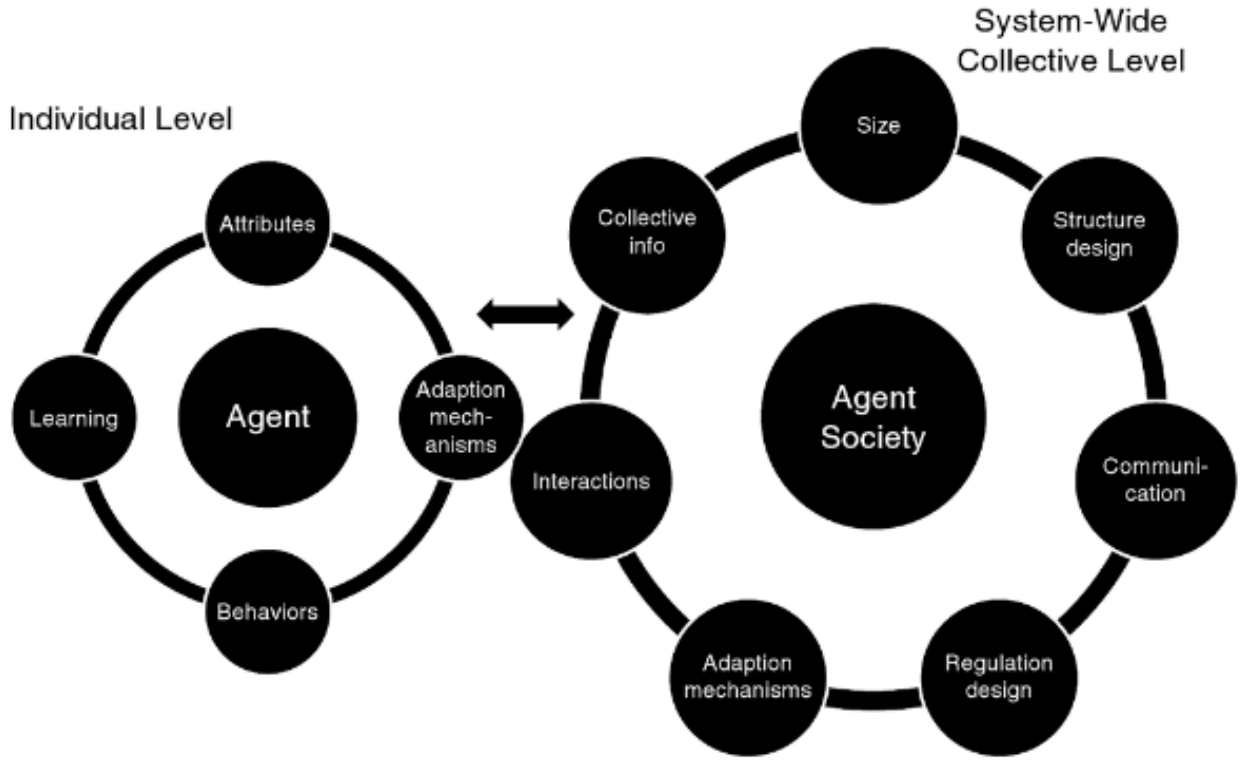
Grouping	Policy Tools	Examples
Supply side	Public enterprise	Innovation by publicly owned industries, setting up of new industries, pioneering use of new techniques by public corporations, participation in private enterprise
	Network and entrepreneurship	Supporting start-ups, establishing science parks and incubators, encouraging collaboration between firms and institutions, venture capital associations, measures to promote entrepreneurship
	Scientific and technical	Research laboratories, support for research associations, learned societies, professional associations, research grants
	Education	General education, universities, technical education, apprenticeship schemes, continuing and further education, retraining
	Information	Information networks and centers, libraries, advisory and constancy services, databases, liaison services
Environmental Side	Financial	Grants, loans, subsidies, financial sharing arrangements, provision of equipment, buildings, or services, loan guarantees, export credits, etc.
	Taxation	Company, personal, indirect and payroll taxation, allowances
	Legal and Regulatory	Patents, environmental and health regulations, inspectorates, monopoly regulations
	Political	Planning, regional policies, honors or awards for innovation, encouragement of mergers or joint consortia, public consultation
Demand Side	Procurement	Central or local government purchases and contracts, public corporations, R&D contracts, prototype purchases
	Public services	Purchases, maintenance, supervision and innovation in health services, public building, construction, transport, telecommunications
	Commercial Trade	Agreements, tariffs, currency regulations
	Overseas agent	Defense sales organizations

Table 11 Innovation Policy Grouping

Appendix 4 ABM Model

Section 1 ABM Conceptualization Approach

Source from (Geyer & Cairney, 2015)



10 ABM Conceptualization Approach

Based on the Geyer Cairney specification of ABM conceptualization approach, the following is a brief description of the Agent-Based Model, deemed necessary for the Policy Formulation exercise under question. The table below identifies the subset description of the ABM modeled.

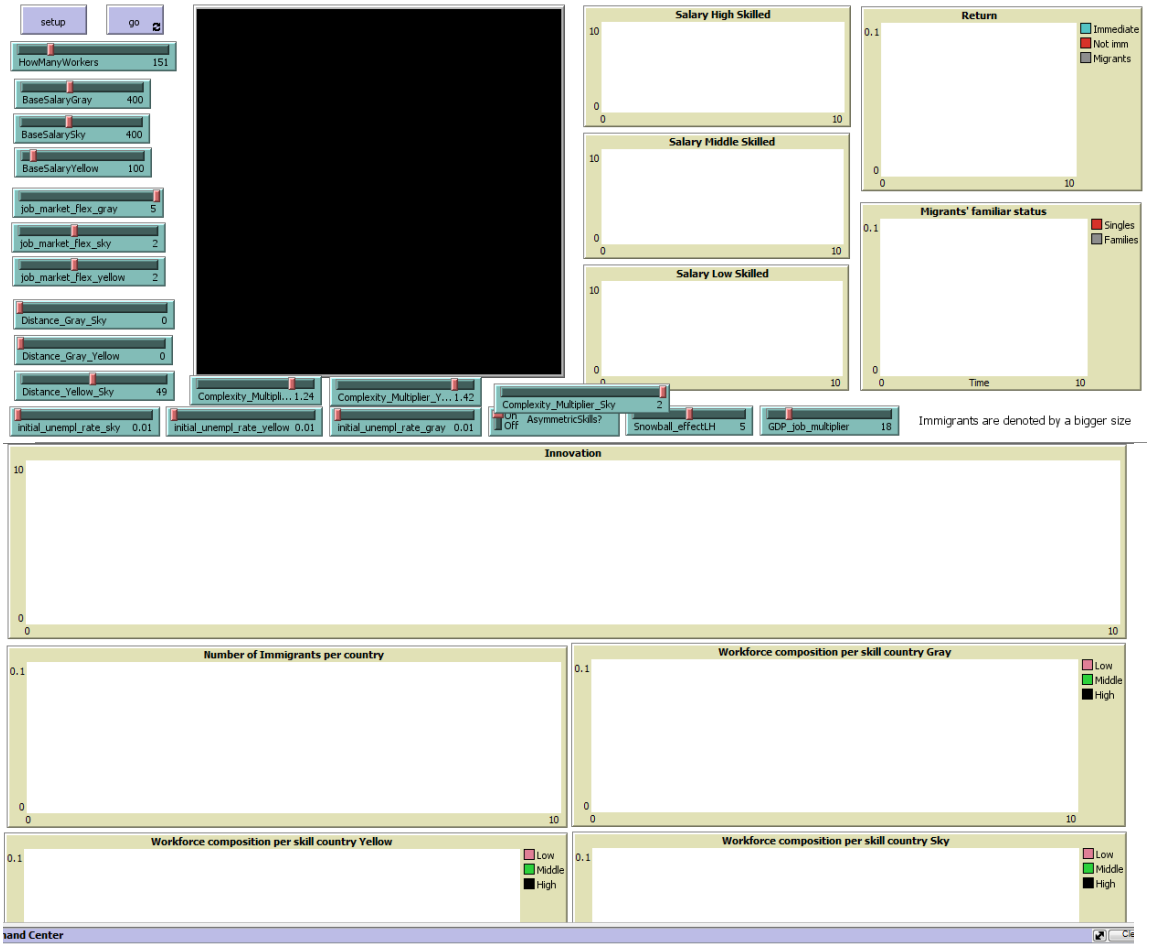
Model Description	
Purpose (goal)	The main scientific, policy, or regulatory question that the model is addressing is if a wage-setting policy may aid in improving high-skilled labor attainment and reduction of the brain drain phenomena in developing countries and its overall effect innovation and economic development.
Breadth	The scope of the model looks at three economies a labor supply developing the economy, a high-income developing economy, and a developed economy. The model is designed to focus narrowly on a small number of social system components or processes, one the family income formation, the cost of migration, the change of income based on immigration in-out flows, the innovational wealth creation, and GDP Wealth impact due to the in-out flows of high-skilled immigration.
Abstraction	The model is designed to be highly abstract, the model assumes that GDP is a result of employment activity; employment activity is the main driving force of social and physical space. While such setting does not match reality, but the model assumes such level of abstraction as it tends to focus on the immigration system only and other relations as derivatives of such policy.

	For advanced realism, the proposed model may be later integrated into a more inclusive model that includes economic activities in the physical space.
Agents Description	
Agent Types	The proposed model is a multi-agent model that incorporates agents such as: Workers; Families; Countries; Personal Wealth; Family Wealth; High Skilled Salary Per Country; Medium Skilled Salary; Low-Skilled Salary GDP Wealth Per Country; Innovation Wealth Per Country; Unemployment Per Country; Job Diversity Per Country; Average Actual High Skilled Salary Level per Country; Average Actual Medium Skilled Salary Level Per Country; Average Actual Low-Skilled Salary Level Per Country;
Agent Definition	• Workers; Families; "People" • Countries; "Physical Space" • Personal Wealth; Family Wealth; "Economic Drivers" • High Skilled Salary Per Country; Medium Skilled Salary; Low-Skilled Salary "Economic Drivers" • GDP Wealth Per Country; "Economic Drivers" • Innovation Wealth Per Country; "Economic Drivers" • Unemployment Per Country; "Economic Drivers" • Job Diversity Per Country; "Economic Drivers" • Average Actual High Skilled Salary Level per Country; "Economic Drivers" • Average Actual Medium Skilled Salary Level Per Country; "Economic Drivers" • Average Actual Low-Skilled Salary Level Per Country; "Economic Drivers"
Data & Theories	
Data Rules	• GDP Growth Influenced Innovation Wealth Creation • GDP Growth Influenced Job Creation • Population growth of certain Skill level Growth Influenced Salary Competition • Population growth of all Skill level unemployment summed up national unemployment • Economic Complexity Increased Multiplier Effects • Innovation Wealth Increased Economic Complexity • Innovation Wealth Increased due to Immigration of Skilled Labor
Data—characteristics	Empirical data were used to inform the characteristics of the agents And environment
Data—validation	Empirical data were used to validate model results, Growth patterns were utilized in the three-country model framework, and a validation of pattern of growth was actually noted.
Theories	• ABMs may be a useful tool to aid in decision making by policy makers (Wallace, Geller, & Ogawa, 2015) • Skilled Immigration Causes GDP Growth (Actual Policy H1B1 Visa US) • Brain Drain and Economics (Abdelbaki, 2009) • GDP Investment and employment (Carmignani, 2014) • Innovation & Growth (Schumpter J. , 1912) • GDP and Fiscal Multipliers (Ilzetzki, Mendoza, & Végh, 2011) • Innovation through Patents increased due to Skilled Labor Migration and International Students (Chellaraj, Maskus, & Mattoo, 2005)
Context	
Physical space	Is represented by a country; each country has limited GDP level that may only expand through innovation.
Social space	The only social space modeled are families relation, each family with the same name may be considered as an entity during immigration decision making.
Physical dynamics	The physical space of countries economic drivers can be expanded by two drivers, High-skilled labor level as an innovation driver to GDP levels. In this model referred to internal effects.
Social dynamics	The social space is dynamic as it allows natives of other nations to immigrate to any country. The model, however, restricts such open immigration behavior by wage setting. Also distinguished in the models as internal effects and external effects.
Outcomes	

Primary outcome	The primary outcomes that are being modeled: Innovation Capital • GDP Wealth Growth • Innovation Wealth Growth • The Evolution of Wage Level due to a wage-setting policy
Proximal/distal outcome	• The primary outcome that is being modeled is the ratio of High-skilled labor formation in different countries. • GDP Growth differential due to Brain Drain Minimization • GDP Growth differential due to a Demand Driven Policy to Innovation
Policy	
Policy definition	• A multi-facet Innovation enabling the policy for the developing world exhibiting higher income -levels.
Policy realism	• 05/11/1976 Public law 94-282 of the United States is reflected in the Strategy for American innovation released in February 20111 • HIB1 Visa Offering by the US Government to High Skilled Labor Attainment strategy • Resulting Economic Salary offering differential between Leading and lagging economies and their innovation impact
Policy tests	• The model will examine inducing demand driver mechanism for innovation for trailing economies. • The model will examine inducing wage setting mechanism for innovation for trailing economies.
Communication	
Model sharing	The model will be publicly available, by correspondence. As I am interested in building a network of experts and practitioners in this modeling field.

Table 12 Model Description

Section 2 ABM Model Components



####CODE#################Base Code Courtesy of Matteo Assandri, and Noemi Oggero

```
breed [workers worker]
workers-own [actual-salary actual-familyIncome salaryGray salarySky salaryYellow familySalaryYellow
familySalaryGray familySalarySky
  skills
  native-country
  familyN myFamily
  personal-costs family-costs
  away immediate-return return long-away
  ]

patches-own [salaryL salaryM salaryH jobL jobM jobH BaseSalary
  GDP GDPlag
  job_market_flex initial_unempl_rate
  Innovation
  Complexity_Multiplier
```

```
]

to setup
  clear-all
  setup_countries
  setup_workers
  setup_salaries
  setup_costs
  collect_info
  setup_job_market
  setup_famliar_salaries
  reset-ticks
end

to go
  update_job_market
  collect_info
  update_familiar_salaries_and_costs
  migrate
  setup_costs
  update_GDP_GDPlag
  tick

end

to setup_countries

  ask patches [if pxcor > 0 and pycor > 0 [set pcolor gray  ]]
  ask patches [if pxcor < 0 and pycor > 0 [set pcolor yellow  ]]
  ask patches [if pxcor <= 9 and pxcor > -9 and pycor < 0 [set pcolor sky ]]

  ask patches with [pcolor = sky] [set BaseSalary BaseSalarySky]
  ask patches with [pcolor = yellow] [set BaseSalary BaseSalaryYellow]
  ask patches with [pcolor = gray] [set baseSalary BaseSalaryGray]

  ask patches with [pcolor = sky] [set initial_unempl_rate initial_unempl_rate_sky]
  ask patches with [pcolor = yellow] [set initial_unempl_rate initial_unempl_rate_yellow]
  ask patches with [pcolor = gray] [set initial_unempl_rate initial_unempl_rate_gray]

  ask patches with [pcolor = sky] [set Complexity_Multiplier Complexity_Multiplier_sky]
  ask patches with [pcolor = yellow] [set Complexity_Multiplier Complexity_Multiplier_yellow]
  ask patches with [pcolor = gray] [set Complexity_Multiplier Complexity_Multiplier_gray]

end

to setup_workers
```

```
  create-workers HowManyWorkers


    ask workers [set shape "person" move-to one-of patches with [pcolor = one-of [gray yellow sky]] set
native-country pcolor]


    ifelse AsymmetricSkills? [Asymmetric_setup_skills] [Symmetric_setup_skills]


    ask workers[

    ;assign each worker a "surname". Workers can only have the same surname within a country

    if pcolor = gray [ set familyN random(count(workers with [pcolor = gray])) + 500]
    if pcolor = yellow [ set familyN random(count(workers with [pcolor = yellow])) + 2000]
    if pcolor = sky [ set familyN random(count(workers with [pcolor = sky])) + 3000]
    ]

     ask workers [set myFamily workers with [familyN = [familyN] of myself ]]

end

to Asymmetric_setup_skills

  ;assign each worker a skill level. The distribution is assumed different in each country

  let developed [pcolor] of one-of patches with [BaseSalary = max (list BaseSalaryYellow BaseSalaryGray
BaseSalarySky)]
  let developing [pcolor] of one-of patches with [BaseSalary = min (list BaseSalaryYellow BaseSalaryGray
BaseSalarySky)]


  ask workers with [pcolor = developed] [let x random-float 1
     if x <= 0.25 [set skills 3 set color blue]
     if x > 0.25 and x <= 0.85  [set skills 2 set color white ]
     if x > 0.85  [set skills 1 set color pink]
   ]
  ask workers with [pcolor = developing] [let x random-float 1
     if x <= 0.10 [set skills 3 set color blue]
     if x > 0.10 and x <= 0.50 [set skills 2 set color white ]
     if x > 0.50  [set skills 1 set color pink]
   ]
  ask workers with [pcolor != developed and pcolor != developing][let x random-float 1
     if x <= 0.15 [set skills 3 set color blue]
     if x > 0.15 and x <= 0.60  [set skills 2 set color white ]
```

```
    if x > 0.60  [set skills 1 set color pink]
   ]


end

to Symmetric_setup_skills

    ;assign each worker a skill level. The same distribution of skills is assumed in each country

    ask workers
   [let x random-float 1
     if x <= 0.15 [set skills 3 set color white]
     if x > 0.15 and x <= 0.45  [set skills 2 set color lime ]
     if x > 0.45  [set skills 1 set color pink]
   ]


end

to setup_costs

  ;personal and familiar costs of migration. Personal costs are lower when outside the native country and
for highly skilled workers

   ask workers [set personal-costs random-float 10
    if pcolor != native-country [set personal-costs personal-costs - 2]
    if skills = 3 [set personal-costs personal-costs - 2]
    if personal-costs < 0 [set personal-costs 0]
   ]
  ask workers [set family-costs sum [personal-costs] of myFamily]
end

to setup_salaries

   ask patches [if pcolor = gray

    ; setup salaries in country gray

    [ set salaryL  200 + BaseSalaryGray -  (count workers with [pcolor = gray and skills = 1] * 2)
      set salaryM  500 + BaseSalaryGray -  (count workers with [pcolor = gray and skills = 2] * (1 / 2))
      set salaryH  2700 + BaseSalaryGray ]

    if pcolor = yellow

    ; setup salaries in country yellow
```

```
    [ set salaryL  200 + BaseSalaryYellow - (count workers with [pcolor = yellow and skills = 1] * 2)
      set salaryM  500 + BaseSalaryYellow - (count workers with [pcolor = yellow and skills = 2]) * (1 / 2)
      set salaryH  900 + BaseSalaryYellow ]

    if pcolor = sky

    ; setup salaries in country sky

    [ set salaryL  200 + BaseSalarySky - (count workers with [pcolor = sky and skills = 1] * 2)
      set salaryM  500 + BaseSalarySky - (count workers with [pcolor = sky and skills = 2] * (1 / 2))
      set salaryH  900 + BaseSalarySky ]


    ]

end

to setup_job_market ;

  ask patches with [pcolor = Sky][set GDPlag BaseSalarySky * (count workers with [pcolor = sky]) / 2]
  ask patches with [pcolor = gray][set GDPlag BaseSalaryGray * (count workers with [pcolor = gray]) / 2]
  ask patches with [pcolor = yellow][set GDPlag BaseSalaryYellow * (count workers with [pcolor =
yellow]) / 2]
  ask patches [set GDP sum [actual-salary] of workers with [pcolor = [pcolor] of myself] ]

  ask patches [let x count workers with [skills = 1 and pcolor = [pcolor] of myself]
            let y count workers with [skills = 2 and pcolor = [pcolor] of myself]
            let z count workers with [skills = 3 and pcolor = [pcolor] of myself]


            set jobL round(x - x * initial_unempl_rate)
            set jobM round(y - y * initial_unempl_rate)
            set jobH round(z - z * initial_unempl_rate)
            ]

  ask patches with [pcolor = sky] [set job_market_flex job_market_flex_sky]
  ask patches with [pcolor = yellow] [set job_market_flex job_market_flex_yellow]
  ask patches with [pcolor = gray] [set job_market_flex job_market_flex_gray]

end

to setup_famliar_salaries

   ask workers[
```

```
  ;each worker earns the salary of its category and the total salary of the family is computed

  if skills = 1 [set actual-salary [salaryL] of patch-here]
  if skills = 2 [set actual-salary [salaryM] of patch-here]
  if skills = 3 [set actual-salary [salaryH] of patch-here]]

 ask workers [  set actual-familyIncome (sum [actual-salary] of myFamily)]

 ask workers [let x count workers with [pcolor = [pcolor] of myself]
          let tot_jobs [jobL] of patch-here + [jobM] of patch-here + [jobH] of patch-here
          let prob_employment tot_jobs / x

     set actual-familyIncome actual-familyIncome * min (list 1 prob_employment)

 ]


 ask workers [let x count workers with [pcolor = yellow]
          let tot_jobs [jobL] of one-of patches with [pcolor = yellow] + [jobM] of one-of patches with
[pcolor = yellow] + [jobH] of one-of patches with [pcolor = yellow]
          let prob_employment tot_jobs / (x + 0.001)

     set familySalaryYellow familySalaryYellow * min (list 1 prob_employment)

 ]

  ask workers [let x count workers with [pcolor = gray]
          let tot_jobs [jobL] of one-of patches with [pcolor = gray] + [jobM] of one-of patches with [pcolor
= gray] + [jobH] of one-of patches with [pcolor = gray]
          let prob_employment tot_jobs / (x + 0.001)

     set familySalaryGray familySalaryGray * min (list 1 prob_employment)

 ]
  ask workers [let x count workers with [pcolor = sky]
          let tot_jobs [jobL] of one-of patches with [pcolor = sky] + [jobM] of one-of patches with [pcolor
= sky] + [jobH] of one-of patches with [pcolor = sky]
          let prob_employment tot_jobs / (x + 0.001)

     set familySalarySky familySalarySky * min (list 1 prob_employment)

 ]
  ask workers [set actual-familyIncome (sum [actual-salary] of myFamily)
           set familySalarySky (sum [salarySky] of myFamily) set familySalaryGray (sum [salaryGray] of
myFamily) set familySalaryYellow (sum [salaryYellow] of myFamily)
```

```
    ]
end


to collect_info

  ; workers internalize the informations about salaries in other countries

  ask workers with [pcolor = gray][

   if skills = 1 [set SalaryYellow [salaryL] of one-of patches with [pcolor = yellow] set SalarySky [salaryL] of one-of patches with [pcolor = sky] set SalaryGray [salaryL] of one-of patches with [pcolor = gray]]
   if skills = 2 [set SalaryYellow [salaryM] of one-of patches with [pcolor = yellow] set SalarySky [salaryM] of one-of patches with [pcolor = sky] set SalaryGray [salaryM] of one-of patches with [pcolor = gray]]
   if skills = 3 [set SalaryYellow [salaryH] of one-of patches with [pcolor = yellow] set SalarySky [salaryH] of one-of patches with [pcolor = sky] set SalaryGray [salaryH] of one-of patches with [pcolor = gray]]

  ]

  ask workers with [pcolor = yellow][

   if skills = 1 [set SalaryGray [salaryL] of one-of patches with [pcolor = gray] set SalarySky [salaryL] of one-of patches with [pcolor = sky] set SalaryYellow [salaryL] of one-of patches with [pcolor = yellow]]
   if skills = 2 [set SalaryGray [salaryM] of one-of patches with [pcolor = gray] set SalarySky [salaryM] of one-of patches with [pcolor = sky] set SalaryYellow [salaryM] of one-of patches with [pcolor = yellow]]
   if skills = 3 [set SalaryGray [salaryH] of one-of patches with [pcolor = gray] set SalarySky [salaryH] of one-of patches with [pcolor = sky] set SalaryYellow [salaryH] of one-of patches with [pcolor = yellow]]

  ]

  ask workers with [pcolor = sky][

   if skills = 1 [set SalaryGray [salaryL] of one-of patches with [pcolor = gray] set SalaryYellow [salaryL] of one-of patches with [pcolor = yellow] set SalarySky [salaryL] of one-of patches with [pcolor = sky]]
   if skills = 2 [set SalaryGray [salaryM] of one-of patches with [pcolor = gray] set SalaryYellow [salaryM] of one-of patches with [pcolor = yellow] set SalarySky [salaryM] of one-of patches with [pcolor = sky]]
   if skills = 3 [set SalaryGray [salaryH] of one-of patches with [pcolor = gray] set SalaryYellow [salaryH] of one-of patches with [pcolor = yellow] set SalarySky [salaryH] of one-of patches with [pcolor = sky]]

  ]

end

to migrate

  ; we mark with return = 1 workers that are returning in the native country after a period abroad
```

```
  ; with immediate-return = 1 workers that are subject to the immediate return phoenomenon (i.e.
migrate and return in the same cycle),
  ; with away = 1 workers that have moved from their native country in the current cycle
  ; with long-away = 1 workers that in the previous cycle were not in their native country

  ask workers [set return 0 set immediate-return 0 ]

  ask workers with [pcolor = gray][

  if actual-FamilyIncome < FamilySalaryYellow - Distance_Gray_Yellow - family-costs and
FamilySalaryYellow - Distance_Gray_Yellow > FamilySalarySky - Distance_Gray_Sky
   [set size 2 set away 1 move-to one-of patches with [pcolor = Yellow]
   ask myFamily [set size 2 set away 1 move-to one-of patches with [pcolor = yellow]]]
   if actual-FamilyIncome < FamilySalarySky - Distance_Gray_Sky - family-costs  and FamilySalaryYellow -
Distance_Gray_Yellow < FamilySalarySky - Distance_Gray_Sky
   [set size 2 set away 1 move-to one-of patches with [pcolor = Sky]
    ask myFamily [ set size 2 set away 1 move-to one-of patches with [pcolor = sky]]]
  ]

  ask workers with [pcolor = sky][

   if actual-FamilyIncome < FamilySalaryYellow - Distance_Yellow_Sky - family-costs  and
FamilySalaryYellow - Distance_Yellow_Sky > FamilySalaryGray - Distance_Gray_Sky
   [set size 2 set away 1 move-to one-of patches with [pcolor = Yellow]
     ask myFamily [set size 2 set away 1 move-to one-of patches with [pcolor = yellow]]]
   if actual-FamilyIncome < FamilySalaryGray - Distance_Gray_Sky - family-costs  and FamilySalaryYellow -
Distance_Yellow_Sky < FamilySalaryGray - Distance_Gray_Sky
   [set size 2 set away 1 move-to one-of patches with [pcolor = Gray]
     ask myFamily [set size 2 set away 1 move-to one-of patches with [pcolor = gray]]]
  ]

  ask workers with [pcolor = yellow][

   if actual-FamilyIncome < FamilySalarySky - Distance_Yellow_Sky - family-costs and FamilySalarySky -
Distance_Yellow_Sky > FamilySalaryGray - Distance_Gray_Yellow
   [set size 2 set away 1 move-to one-of patches with [pcolor = Sky]
     ask myFamily [set size 2 set away 1 move-to one-of patches with [pcolor = sky]]]
   if actual-FamilyIncome < FamilySalaryGray - Distance_Gray_Yellow - family-costs  and FamilySalarySky -
Distance_Yellow_Sky < FamilySalaryGray - Distance_Gray_Yellow
   [set size 2 set away 1 move-to one-of patches with [pcolor = Gray]
     ask myFamily [set size 2 set away 1 move-to one-of patches with [pcolor = gray]]]
  ]


  ; the immediate return phenomenon is assumed typical of singles and more likely among low-skilled
```

```
  ask workers with [away = 1 and count myFamily = 1 and skills != 3][let x random-float 1
    if x < 0.10 [set immediate-return 1 set size 1 move-to one-of patches with [pcolor = [native-country]
of myself]]]

  ask workers with [away = 1 and count myFamily = 1 and skills = 3][let x random-float 1
    if x < 0.05 [set immediate-return 1 set size 1  move-to one-of patches with [pcolor = [native-country]
of myself]]]


  ask workers [if long-away = 1 and pcolor = native-country [set return 1 set long-away 0 set size 1 ]]

  ask workers with[away = 1 ] [set long-away 1 set away 0]



end


to update_familiar_salaries_and_costs

  ask workers [set familySalarySky (sum [salarySky] of myFamily) set familySalaryGray (sum [salaryGray]
of myFamily) set familySalaryYellow (sum [salaryYellow] of myFamily)]

  ask workers[  set family-costs sum [personal-costs] of myFamily]

   ;each worker earns the salary of its category and the total salary of the family is computed

  ask workers[
   if skills = 1 [set actual-salary [salaryL] of patch-here]
   if skills = 2 [set actual-salary [salaryM] of patch-here]
   if skills = 3 [set actual-salary [salaryH] of patch-here]]

  ask workers [set actual-familyIncome (sum [actual-salary] of myFamily)]


  setup_famliar_salaries

end

to update_job_market

 ask patches [let deltaGDP GDP - GDPlag
          let deltaJob (GDP_job_multiplier * deltaGDP) / 1500000
          let x count workers with [skills = 1 and pcolor = [pcolor] of myself]
          let y count workers with [skills = 2 and pcolor = [pcolor] of myself]
          let z count workers with [skills = 3 and pcolor = [pcolor] of myself]
```

```
  ; as GDP increases, new jobs are created

  if deltaGDP > 0 [set jobL jobL + deltaJob set jobM jobM + deltaJob set jobH jobH + deltaJob

  ; and the effect is greater for the category in which the country is already specialized

  if x > y and x > z [set jobL jobL + deltaJob / 3]
  if y > x and y > z [set jobL jobM + deltaJob / 3]
  if z > x and z > y [set jobL jobH + deltaJob / 3]

  ; new jobs for highly skilled people are likely to create new jobs for low skilled ones

  set jobL jobL + deltaJob * snowball_effectLH]

  ; then the change in the number of jobs has an effect on salaries

  if x != jobL [set salaryL salaryL + [job_market_flex] of self * (jobL - x)]
  if y != jobM [set salaryM salaryM + [job_market_flex] of self * (jobM - y)]
  if z != jobH [set salaryH salaryH + [job_market_flex] of self * (jobH - z)]


  ]
   ask workers[

  if skills = 1 [set actual-salary [salaryL] of patch-here]
  if skills = 2 [set actual-salary [salaryM] of patch-here]
  if skills = 3 [set actual-salary [salaryH] of patch-here]
  ]


end

to update_GDP_GDPlag

  ask patches [set GDPlag GDP]
  ask patches [set GDP sum [actual-salary] of workers with [pcolor = [pcolor] of myself]  ]

ask patches [set Innovation salaryH  * Complexity_Multiplier * (count workers with [skills = 3]) ]

end
```

Section 3 Model Setting

The Model Initial Conditions & Interactions

To better model, the relationships between agents, outputs, and emerging behaviors, the model considers published scientific findings. Such findings were then introduced in the model as instrument structures into the especially explicit ABM, but for some relations, there were no scientific data that targets developing nations, or even concrete findings published in relations to the modern concepts perceived as influential but are yet to be parameterized. To that end the modeling was sensitive to such relations as to leaving them as parameterized inputs, hence providing capabilities for adjustment and identifying whether such inputs could be influential at which levels require future research.

The main concepts modeled are listed in the below table with references to their sources.

Initial Conditions Modelled	Source of Concept Finding	Modeling Approach Considered
Base_Salary	http://www.payscale.com Actual Statistics http://www.ilo.org/global/research/global-reports/global-wage-report/2016/WCMS_537846/lang--en/index.htm	• List Of Salaries for High, Medium, Low Skills For Country A, B, C See Appendix 2 Section 1 • Base_Salary_Country Adjuster For Country A, B, C See Appendix 2 Section 2
Initial_unempl_rate	http://data.worldbank.org/indicator/SL.UEM.TOTL.ZS	• initial_unempl_rate Adjuster For Country A, B, C See Appendix 2 Section 3 A 0.003 B 0.036 C 0.069
job_market_flex_Country	http://www.oecd.org/els/emp/oecdindicatorsofemploymentprotection.htm	• job_market_flex_Country Adjuster For Country A, B, C See Appendix 2 Section 4 A 1.6 B 2.6 C 1.9
GDP_Economic_Multiplier	How Big (Small?) are Fiscal Multipliers? (Ilzetzki, Mendoza, & Végh, 2011)	• GDP JOB Multiplier • Impulse Response Relation See Appendix 2 Section 4 A 0.5 B -0.26 “Debt Economy” C 1.5
GDP_Job_Multiplier	Does Government Expenditure Multiply Output and Employment in Australia?	• GDP JOB Multiplier See Appendix 2 Section 4 Impulse Table

	(Carmignani, 2014)	See Appendix 2 Section 5
GDP Level	WorldBank	• GDP Level See Appendix 2 Section 6 A 206 **Billion** B 2.095 Trillion C 1.511 Trillion
GDP_Natural_Growth_Rate	WorldBank	• Country Population See Appendix 2 Section 8 A 4.5% B 8.0% C 2.3%
Country_Population	WorldBank	• Country Population See Appendix 2 Section 8 A2.23 Million B 1.311 Billion C 35Million
Population_Growth_Rate		
Economic_Complexity_by_Country	(Hausmann, Hidalgo, Bustos, & Coscia, 2007)	• GDP JOB Multiplier See Appendix 2 Section 9 A 0.24 B 0.41 C 1.20

Table 13 Model Initial Conditions

Primitive Interactions Modelled	Source of Concept Finding	Modeling Approach Considered
External Effects of Brain Drain of Labor-Loss of Productivity	(Abdelbaki, 2009) (Borjas, 1995)	• Is not Identified as Scientific Finding • Parametrized as Sliding Parameter between 1 and 20%
External Effects of Brain Drain of Labor-Loss of Productivity	(Abdelbaki, 2009) (Borjas, 1995)	• Is not Identified as Scientific Finding for all types of economies, only leading economy level identified as .0036 • Parametrized as Sliding Parameter between 1 and 20%
External Effects of Brain Drain of Labor-Losses of national scientists.	(Abdelbaki, 2009) (Borjas, 1995)	• An applied study demonstrated that 10% induction of immigrant skilled workers increased patents by 1.3% • Parametrized as Sliding Parameter between 0

		and 2%
External Effects of Brain Gain_due_to_Immigrant_ skilled_Labor	(Chellaraj, Maskus, & Mattoo, 2005)	• An applied study demonstrated that 10% induction of immigrant skilled workers increased patents by 1.3% • Parametrized as Sliding Parameter between 0 and 2%
External Effects Immigration Decision	(Abdelbaki, 2009) (Borjas, 1995)	• Cost Based Function • Random Immigration Decision reversal
Internal Effects Unemployment Natural Level Force	System Driven	• Cost Based Function
Internal Effects of Accumulated GDP Growth	System Driven • Based on Immigration Induction/Reduction • Economic Complexity • GDP Job Multiplier	System Emerged Behavior
Internal Effects of Unemployment Level	System Driven • Based on Immigration Induction/Reduction • GDP Emerged behavior • Economic Complexity • GDP Job Multiplier	System Emerged Behavior
Internal Effects of Accumulated Innovation Growth	System Driven • Based on Immigration Induction/Reduction • GDP Emerged behavior • Economic Complexity • GDP Job Multiplier	System Emerged Behavior
Internal Effects of Skill Level Growth	System Driven • Based on Immigration Induction/Reduction • GDP Emerged behavior • Economic Complexity • GDP Job Multiplier	System Emerged Behavior
Internal Effects of Innovation_Wealth_Growth	System Driven • Based on Immigration Induction/Reduction • GDP Emerged behavior • Economic Complexity • GDP Job Multiplier	System Emerged Behavior

Internal Effects of Economic Complexity	System Driven • Based on Immigration Induction/Reduction • GDP Emerged behavior • Innovation Wealth	System Emerged Behavior

Table 14 Model Interactions

Model Macro-Behavior

Simulating Immigration is permitting the workers (agents) to change native country based on economic choice and logic. Such activity becomes as an attractor for a specific type of workers based on economic income differentials in basic salaries to be attracted to move from one country to another. Such activity creates an emerging behavior in wage setting as economic growth is not linear in an economy based only on the economy, the growth is apparent to be from the model as an emerged behavior on workers demographics of skills, and economic complexity,

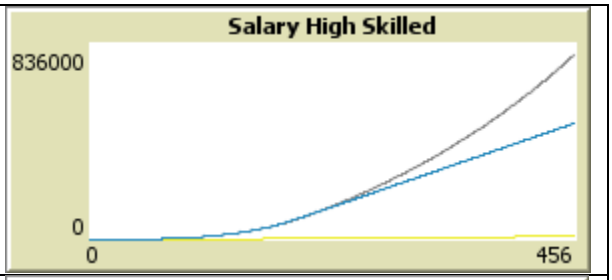
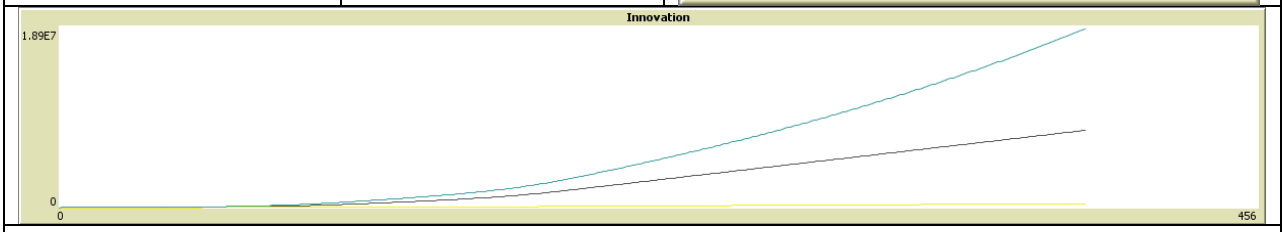
Table 15 Original Model With WorldBank Settings

Permitted Immigration	**Skill Level**	**Sky Country Emerging Salaries Levels**	**Gray Country Emerging Salaries Levels**	**Yellow Country Emerging Salaries Levels**
Yes	High	3	2	0
	Medium	3	2	0
	Low	3	2	0
Innovation		First	Second	Third
Notable Initial Conditions: • **Distance of countries the same** • **Base Price Differential 0** • **Economies Different** • **Economic Complexities Different** • **Worker Skills Demographics Different** • **Open (Job Global Competition)**				

Appendix 5 ABM - Simulation Results

Section 1 Policy Immigration Permitted Brain-Drain

Table 16 Policy Immigration Permitted Brain-Drain

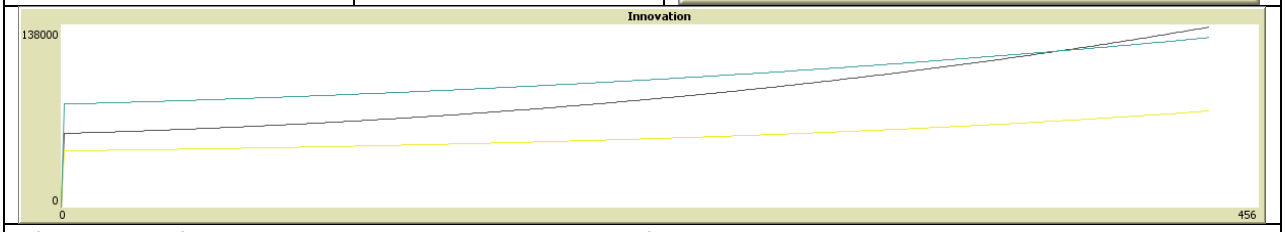
<table>
<tr>
<td>Immigration Permitted: What is meant by immigration permitted is an open market competition for human capital that allows competing benefits</td>
<td>High Skilled Sky =2
High Skilled Gray =3
High Skilled Yellow=0</td>
<td> 
</td>
</tr>
<tr>
<td></td>
<td>Middle Skilled Sky =2
Middle Skilled Gray =3
Middle Skilled Yellow=0</td>
<td> 
</td>
</tr>
<tr>
<td></td>
<td>Low Skilled Sky =2
Low Skilled Gray =3
High Skilled Yellow=0</td>
<td> 
</td>
</tr>
<tr>
<td colspan="3"> 
</td>
</tr>
<tr>
<td colspan="3">It's apparent from the trend due to the interaction of agents, Immigration policy alone does not promote a converging GDP patterns between gray (transforming economy) and sky (developed economy).

Immigration due to economy growth pattern simulates a brain drain pattern that consequently raises wage patterns for gray (transforming economy) countries without any economic influential benefit.

This is especially an alarming pattern to experience especially that the gray countries are seeking to better diversify their economies into competing in the global economic arena.</td>
</tr>
</table>

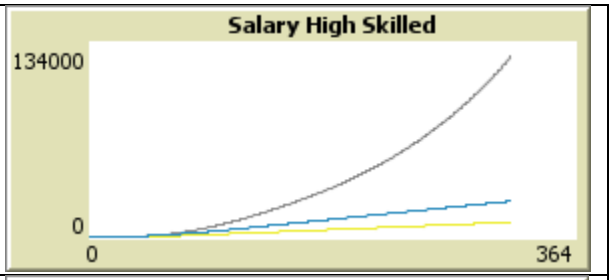
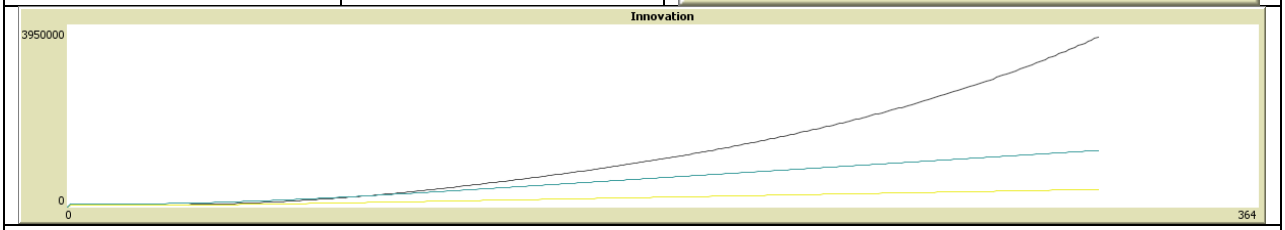
Section 2 Policy Immigration Friction Increased

Table 17 Policy Immigration Friction Increased

Immigration not Permitted; this constitutes a competing promotional policy to minimize if not eliminate brain drain phenomenon for the transitional economy.	High Skilled Sky =2 High Skilled Gray =3 High Skilled Yellow=0	
	Middle Skilled Sky =2 Middle Skilled Gray =3 Middle Skilled Yellow=0	
	Low Skilled Sky =2 Low Skilled Gray =3 High Skilled Yellow=0	
		
It's apparent from the trend due to the interaction of agents, Immigration reduction policy, decreasing brain drain alone not only promotes a converging GDP patterns between gray (transforming economy) and sky (developed economy) but also influences the GDP patterns of the gray (transforming economy) to overtake the sky developed the economy. Competitively competing for high-skilled labor, due to economy growth pattern simulates a brain drain reduction pattern. Which consequently improves both innovation and GDP. Such overall immigration policy of capturing or reducing immigration raises wage patterns for gray (transforming economy) countries for low-skilled labor (group) with the little economic influential benefit if any.		

Section 3 Policy Induced Knowledge Jobs Demand

Table 18 Policy Induced Knowledge Jobs Demand

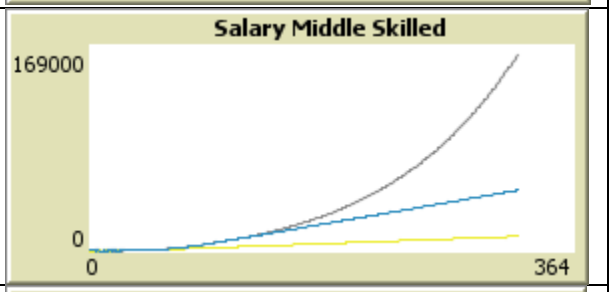
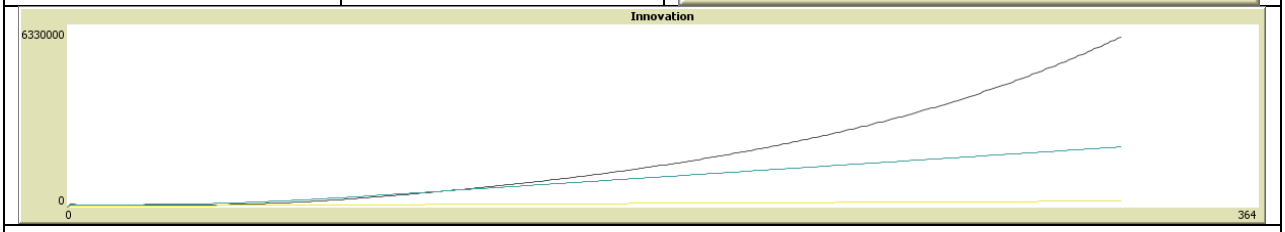
Induced Demand Knowledge Jobs	High Skilled Sky =2 High Skilled Gray =3 High Skilled Yellow=0	
	Middle Skilled Sky =2 Middle Skilled Gray =3 Middle Skilled Yellow=0	
	Low Skilled Sky =2 Low Skilled Gray =3 Low Skilled Yellow=0	
		

Induced demand for knowledge jobs alone, may simulate both innovation and economic growth, such policy may influence the GDP pattern of the gray (transforming economy) to overtake the sky developed the economy. The pattern of growth coupled with an immigration expelling policies significantly increase wage setting for all skills types and (groups). Such exponential growth in all skilled wages may prove to be counterintuitive in the global economic competition perspective.

Induced demand, nevertheless alone may fast-forward the GDP growth pattern and innovation wealth creation.

Section 4 Policy Wage Setting

Table 19 Policy Wage Setting

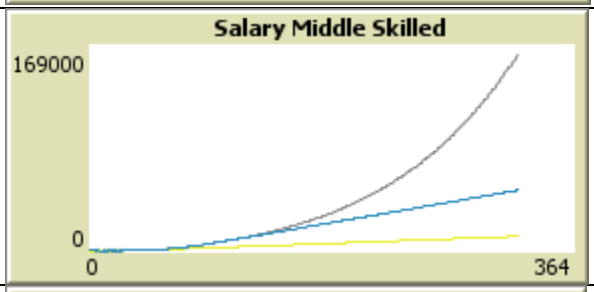
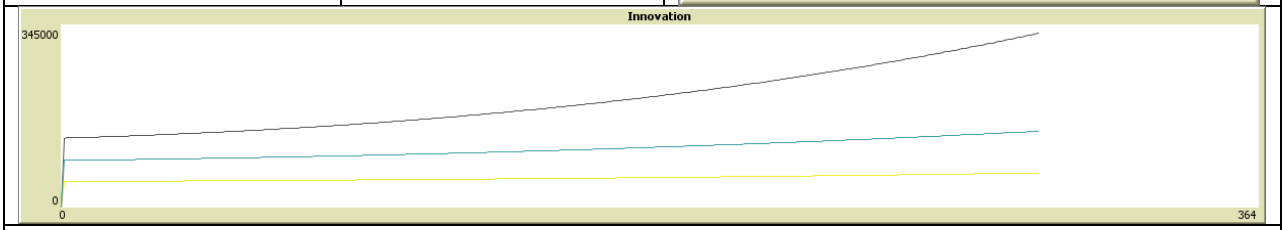
Wage Setting	High Skilled Sky =2 High Skilled Gray =3 High Skilled Yellow=0	
	Middle Skilled Sky =2 Middle Skilled Gray =3 Middle Skilled Yellow=0	
	Low Skilled Sky =2 Low Skilled Gray =3 High Skilled Yellow=0	
		

Induced higher wage setting for skilled labor has a similar effect in converging the growth and quickly simulating economic growth as the induced demand mechanism but has demonstrated double the impact, may simulate both innovation and economic growth, such policy may influence the GDP pattern of the gray (transforming economy) to overtake the sky developed economy. The pattern of growth coupled with an immigration expelling policies significantly increase wage setting for all skills types and (groups). Special attention is to the wage setting levels as they were also doubled for all skill sets. Such exponential growth in all skilled wages may also prove to be further counterintuitive in the global economic competition perspective.

Induced higher wage setting for skilled labor, nevertheless alone may fast-forward the GDP growth pattern and innovation wealth creation.

Section 5 Policy Combinational All Skills

Table 20 Policy Combinational All Skills

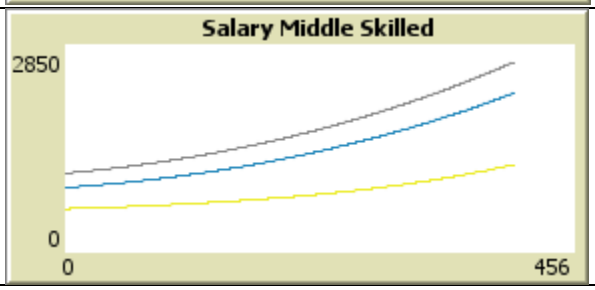
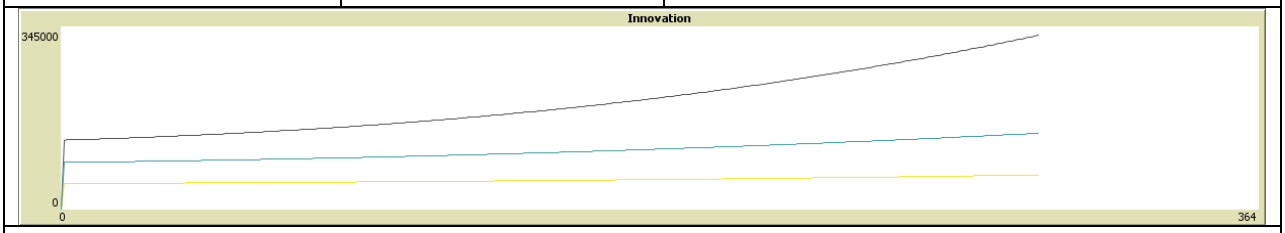
Combinational Policy Absolute all skills Sets	High Skilled Sky =3 High Skilled Gray =2 High Skilled Yellow=0	
	Middle Skilled Sky =3 Middle Skilled Gray =2 Middle Skilled Yellow=0	
	Low Skilled Sky =3 Low Skilled Gray =2 High Skilled Yellow=0	
		

A combination policy of Induced higher wage setting for skilled labor, limiting immigration for all skills sets, and inducing demand has a similar effect in converging the growth and quickly simulating economic growth as the induced demand mechanism but has demonstrated minimal impact on growth while still achieving a win as a comparative approach beating the sky economy.

A combitianol policy adoption nevertheless alone may fast-forward the GDP growth pattern and innovation wealth creation. But especial attention, required for both middle and low-level skill wage increase. Such increase may require maintaining an expulsion pattern for both middle and low-level skills while only concentrating on high-level skill set attainment.

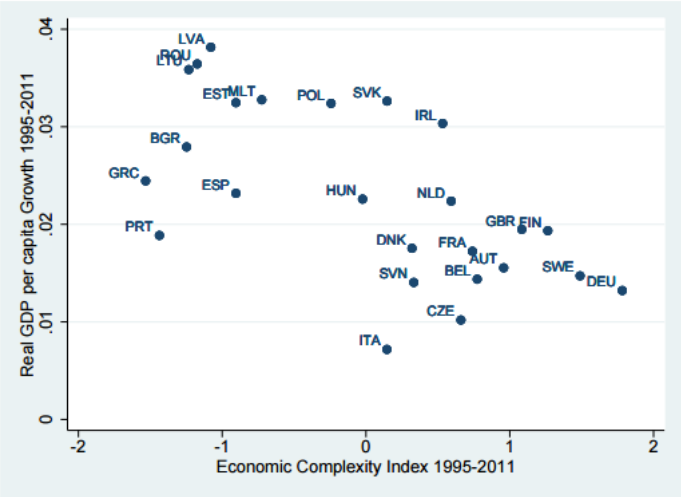
Section 6 Policy Combinational High Skill (Selective)

Table 21 Policy Combinational High Skill (Selective)

Combinational Policy Selective	High Skilled Sky =3 High Skilled Gray =2 High Skilled Yellow=0	
	Middle Skilled Sky =3 Middle Skilled Gray =2 Middle Skilled Yellow=0	
	Low Skilled Sky =3 Low Skilled Gray =2 High Skilled Yellow=0	Maintain Status Quote
		
A combinatianol policy of Induced higher wage setting for skilled labor, limiting immigration for all skills sets, and inducing demand has a similar effect in converging the growth and quickly simulating economic growth as the induced demand mechanism but has demonstrated minimal impact on growth while still achieving a win as a comparative approach beating the sky economy. A comitial policy adoption nevertheless alone may fast-forward the GDP growth pattern and innovation wealth creation. But especial attention, required for both middle and low-level skill wage increase. Such increase may require maintaining an expulsion pattern for both middle and low-level skills while only concentrating on high-level skill set attainment.		

Appendix 6

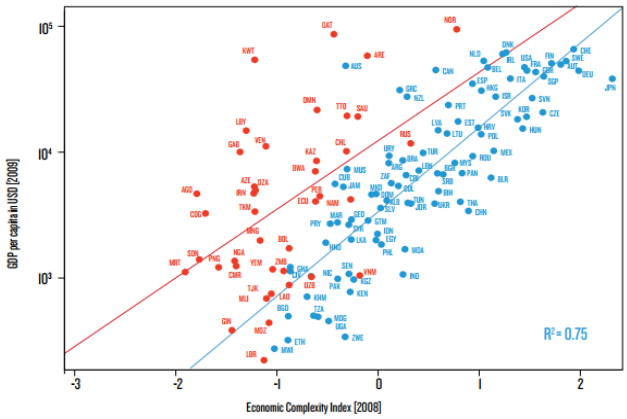
Section 1 Growth & Economic Complexity



12 Growth & Economic Complexity

(Hausmann, C. Hidalgo, M. Coscia, & Chung, 2011) (Ozguzer & Binatlı, 2015)

Section 2 Economic Complexity & GDP Volume



13 Economic Complexity and GDP Volume

(Hausmann, Hidalgo, Bustos, & Coscia, 2007)

	Annualized growth in GDP pc (by decade)	
	(1978-1988, 1988-1998, 1998-2008)	
VARIABLES	(1)	(2)
Initial Income per capita, log	-0.00017	-0.00638***
	(0.001)	(0.001)
Increase in natural resource exports	0.03960***	0.03682***
- in constant dollars (as a share of initial GDP)	(0.008)	(0.010)
Initial Economic Complexity Index (ECI)		0.04430***
		(0.009)
[ECI] X [Income per capita, log]		-0.00371***
		(0.001)
Constant	0.03036***	0.08251***
	(0.008)	(0.011)
Observations	291	291
R^2	0.285	0.434
Year FE	Yes	Yes

Table 22 Annualized GDP Growth by Economic Complexity and Income per ECI*Capita log

(Hausmann, Hidalgo, Bustos, & Coscia, 2007)

(Hausmann, Hidalgo, Bustos, & Coscia, 2007)

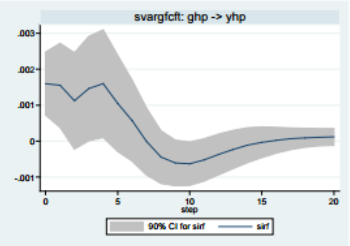
	Annualized growth in GDP pc (by decade)				
	(1978-1988, 1988-1998, 1998-2008)				
VARIABLES	(1)	(2)	(3)	(4)	(5)
Initial Economic Complexity Index (ECI)	0.04430***	0.03005***	0.04240***	0.04143***	0.04389***
	(0.009)	(0.007)	(0.008)	(0.010)	(0.009)
[ECI] X [Income per capita, log]	-0.00371***	-0.00244***	-0.00345***	-0.00354***	-0.00381***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Increase exports (goods and services)		0.04549***			
- in constant dollars (as a share of initial GDP)		(0.007)			
Exports to GDP			0.00009		
			(0.000)		
Export Concentration				-0.00890	
				(0.008)	
Population, log					0.00168
					(0.001)
Initial Income per capita, log	-0.00638***	-0.00562***	-0.00729***	-0.00611***	-0.00558***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Increase in natural resource exports	0.03682***	0.00169	0.03441***	0.03699***	0.03758***
- in constant dollars (as a share of initial GDP)	(0.010)	(0.005)	(0.008)	(0.010)	(0.010)
Constant	0.08251***	0.06741***	0.08616***	0.08145***	0.04878**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.022)
Observations	291	260	284	291	291
R^2	0.434	0.584	0.449	0.436	0.440
Year FE	Yes	Yes	Yes	Yes	Yes

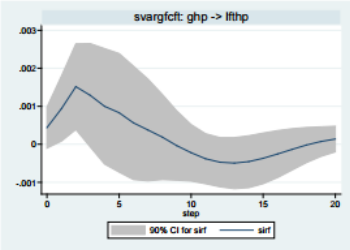
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 23 per decade, Annualized GDP Growth by Economic Complexity and Income per ECI*Capita log

(Hausmann, Hidalgo, Bustos, & Coscia, 2007)

Section 3 Unemployment and GDP





Notes: Percentage change response of GDP (left panel) and employment (right panel) to a 1% shock to government consumption over a period of 20 quarters following the initial impulse. Shaded areas represent 90% confidence intervals. The SVAR is estimated on the full sample Q1 1978 – Q1 2014, employment is measured by full-time employment.

Starting with the panel on the left of Figure 1, the IRF indicates that GDP increases by 0.14% on impact. This response is statistically significant at the 90% confidence level and quantitatively larger than what estimated by Ilzetzki et al. (2013) for the group of high income countries (0.08%). The response remains positive, albeit declining, until quarter 7 after the impulse, then becomes marginally negative before returning to zero at the end of the simulation. It must be however noted that the 90% confidence interval crosses the zero line in all quarters but the first one after the impulse,

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(Carmignani, 2014)

Appendix 7 Table of Figures

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