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**ADAPTIVE DEVELOPMENT:**

**THE MICROGENESIS OF DEVELOPMENT AS ADAPTIVE LEARNING**

A dissertation submitted in partial satisfaction

of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

POLITICS

by

**Gabriel Braga Filártiga**

December 2017

The dissertation of Gabriel Braga Filártiga  
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## Table of Contents

1. Introduction.....	1
2. The Unexplored Role of Adaptive Learning in Political Economy.....	7
2.1. Political Economy, Institutions and Learning .....	9
2.2. From a Theory of Choice to a Theory of Change .....	13
2.3. Learning and Path Dependence in Institutional Change .....	18
2.4. Development and Learning with Institutional Complementarities .....	30
3. Adaptive Learning .....	37
3.1. Development as a Learning Process.....	38
3.2. The Learning Wave .....	44
3.3. Learning Organizations .....	53
3.4. The Production of Social Goods as a Learning System .....	59
4. The Hypothesis of Adaptive Development.....	64
4.1. Analytical Model.....	65
4.2. Methodology .....	70
4.3. Exploring the Data .....	76
5. Path Dependence in Adaptive Development .....	88
5.1. Learning Fitness and Path Dependent Dynamics.....	89
5.2. Power Relations, Complexity and Path Dependence .....	101
5.3. Empirical Evidences and Limitations .....	119
6. Barriers to Learning in Vicious and Virtuous Cycles.....	123
6.1. Process Tracing .....	124
6.2. Case Studies .....	129
6.3. Ambiguity, Dynamic Complexity and Defensiveness .....	142
7. Conclusion .....	147
8. Appendix.....	157
8.1. Logit Model.....	157
8.2. Estimating Fitness .....	158
9. References.....	166

## **Abstract**

### **Adaptive Development: The Microgenesis of Development as Adaptive Learning**

By Gabriel Filártiga

Adaptive efficiency is the product of an evolutionary process in which certain types of learning prevail, locking societies in vicious cycles of underdevelopment or unlocking the path to prosperity. Moving development studies from a theory of choice to a theory of change, this research posits that learning reinforces path dependent processes of underdevelopment and identifies barriers that block the reflective learning types that can unlock society from such patterns. With data about the ability to learn of urban development projects, the empirical analysis studies learning fitness with a model of Evolutionary Game Theory, combined with a process tracing method in case studies. The results present evidence that hierarchical power relations and complexity increase path dependence to unreflective learning and that vicious cycles of underdevelopment are reinforced by ambiguity, defensiveness and misperceptions of dynamic complexity. The conclusion recommends to policy makers a focus shift from just policy design to learning processes.

*To Daniele, Isadora, Mariana, Thadeu, Virginia, Marila and Diego Filártiga.*

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I'm very grateful to the Brazilian Development Bank for this opportunity, especially to Marcelo Fernandes, Ricardo Ramos and my colleagues who kindly shared their experiences as project managers and analysts. I believe this research will contribute to improve our "adaptive efficiency" as an organization in our challenging mission of promoting development in Brazil.

This research as it is wouldn't be possible without the absolute freedom of thought of the University of California in Santa Cruz. Roger Schoenman was since the

beginning enthused by the idea of “learning waves” as our object of study and always encouraged me to be bold in this work. I was very lucky to have him as advisor and thank for his guidance, friendship and suggested readings, particularly Hutchin’s *Cognition in the Wild*. I thank Kent Eaton for his permanent availability to discuss and help me improve concepts and analysis with methodological rigor, both in class and office hours. I thank Eleonora Pasotti for her enthusiasm and insightful comments that were always an extra motivation in the hard times. I also thank Daniel Friedman for the privilege of taking part in his Experimental Economics and Evolutionary Game Theory classes, as well as for his kindness and interest in listening and commenting on the ideas presented in this research. I thank each faculty member of our department for the support, including Robert Meister, Ronnie Lipschutz and Ben Read, as well as Sarah Amador, Tammy Tooley-Chelossi, Maya Woolfe and all the staff members of our university that made my life so smooth during these years.

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## **1. Introduction**

Learning is the microgenesis of development. Individuals, organizations and society change as they learn in the face of ongoing new challenges. The ability to adjust to such dynamic change, what Hayek (1960) and North (2005) called adaptive efficiency, is the product of an evolutionary process in which certain types of learning prevail, locking societies in vicious cycles of underdevelopment or unlocking the path to prosperity. This is a process of adaptive development, the focus of this research.

Great efforts have been made by governments, multilateral organizations, development banks, as well as by all kinds of public and private agents, including the academy, in order to understand and implement solutions to drive less developed societies to prosperity. Prescribed responses in mainstream development theory and public policy are mostly based on incentives and constraints that might produce better choices<sup>1</sup>, usually aiming some sort of institutional improvement and capability building in terms of human and social capital, but when these initiatives fail there is not so much left in the manuals. The persistence of poverty in all continents is the unfortunate evidence that such efforts have been seldom successful. We need a new approach that, more than pointing out institutions and capabilities to be improved, unveils the underlying mechanisms of path dependent processes of underdevelopment.

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<sup>1</sup> North (1990) was very influential in this sense and clearly stated his theory, at that point, as a theory of choice.

Consider this example I had the opportunity to observe “in the wild”. People from a municipality in the heart of the Amazon forest were about to suffer the impact of the massive investment of the Belo Monte hydroelectric plant. I was part of a team whose task was the promotion of coordinated actions that would potentially contribute to mitigating the impact of the expected vast amount of investments. Along environmental issues, the main concerns were related to the deterioration of local living conditions that usually follows large infrastructure projects. One of the first meetings was a festive announcement of a program that would support small farmers. Interested in the project, the government and the contractor consortium presented several actions, one of the most important being a new credit line for investments in equipment and training. However, when the first farmer had the chance to speak, an endless discussion about property rights came about.

The problem of property rights is one of the longest standing, complex and violent in the region. Unlike usual agrarian problems of concentrated land, that area was occupied with several governmental programs that distributed small to medium properties to migrants. The process was confusing and overlapped by national and subnational programs, with some pieces of land having up to eleven different property deeds. The upshot was that the state and the federal government couldn't solve such ambiguities in the short term and, without the proper documentation, a farmer couldn't access the credit loans. Moreover, state and federal government became very defensive and guilty seeking, and the program turned out to be a timid amount of grants for superficial investments.

As explained in institutions theory, high transaction costs related to the property rights barred the investment of the farmers and the region's economic growth. Nevertheless, the ambiguity created by the government decades ago also affected the possible reflective solutions for the problem. Without a proper reflection upon the deep causes of the property rights dilemma, the incentives offered by the new program to local development became innocuous. Revolving in an unreflective learning cycle that historically dealt just with the symptoms of the problem, no farmer, citizen, technocrat or politician seemed to be clear about the underlying structure that kept the situation path dependent. Furthermore, political disputes between state and federal government and even new attempts to map the property entitlements in the region seemed to increase complexity, ambiguities, defensive behaviors and potential conflicts.

This snapshot of a long story should be enough to motivate a series of questions to push the boundaries of the available literature based on incentives and constraints. Why didn't agents learn from the experience and coordinate a solution? What locked them in a path in which no reflective solution could emerge for so long? What produced so much defensiveness and guilty seeking? Did ambiguity block reflective learning rather than just increase uncertainty for investment commitments? To what extent it was all a matter of complexity? I believe the missing part of this puzzle is the understanding of the dynamics of the political economy of development. More than the static influence of institutions and capabilities driving choices, we should try to grasp the dynamics of the process of learning from experience, decision after decision. This research takes adaptive

learning as a fundamental process for understanding social change within the political economy of development.

The starting point is the idea that development is an evolutionary process of trials, errors, learning and adaptation<sup>2</sup>. The keystone is the concept of learning as a process of adaptive reorganization<sup>3</sup> that links the microgenesis of capabilities and institutions to the production of social goods. The empirical questions are whether learning is the source of path dependent processes of underdevelopment and, if so, what barriers block the reflective learning types that would possibly unlock societies from such patterns.

Chapter 2 is an inquiry about the role of adaptive learning in the literature of political economy. I study the approaches based on interests, institutions and culture, as typified by Hall (1997), to figure out whether they are still limited to explanations about how political and economic choices are framed. I also try to find the dynamics of learning in the debates on path dependence<sup>4</sup>, institutional change and institutional complementarities<sup>5</sup>. What does the literature say about learning as a source of path dependence?

Chapter 3 is a search for the ideas that might fill the gap of the unexplored role of adaptive learning found in the literature. It is an interdisciplinary study with references from Political Economy, Economics, Psychology, Anthropology and

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<sup>2</sup> As Hayek (1960) suggests.

<sup>3</sup> A definition proposed by Hutchins (1995).

<sup>4</sup> As developed by North (1990) and Pierson (2004).

<sup>5</sup> As discussed by Mahoney and Thelen (2010) and in the theory of Varieties of Capitalism.

Organizational theories<sup>6</sup> in order to build the concepts of development and learning that drive this research. I suggest an evolutionary approach with emphasis on organizational learning as a step further the usual explanations of the primary causes of development and adopt a concept of learning beyond individual and disciplinary bounds.

Chapter 4 turns to the empirical part of the research, defining learning fitness as the dependent variable; power relations, complexity and the artifactual structure of capabilities and institutions as independent variables; as well as the barriers to learning as intervening variables. I translate the dynamics of adaptive learning into an analytical model in which development is the product of virtuous or vicious cycles and unfold my empirical questions in three hypotheses. The methodology section presents the quantitative and qualitative approaches of this research project: a large N study of learning fitness and a process tracing case study on the barriers to learning. The first starts with a section for exploring a data set of 172 projects of water & sanitation and a model to estimate the odds of certain power relations, levels of complexity and local development to produce reflective learning.

The quantitative stage continues in Chapter 5 with a model of Evolutionary Game Theory to estimate learning fitness. This model was first developed by Friedman, Paranjpe, Magnani and Sinervo (2016) for studying lizards' mating strategies, but the adaptation for learning types was quite suitable. I use the model to examine

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<sup>6</sup> Principally Hayek (1960), North (2005), Nelson and Winter (1982), Hutchins (1995) and Argyris and Schön (1978).

two hypotheses: (i) learning is a source of path dependence in the process of development; (ii) hierarchical power relations and complexity increase path dependence to unreflective learning.

Conducted in Chapter 6, the second stage is a qualitative analysis of hypothesis (iii): vicious cycles of unreflective learning are reinforced by ambiguity, defensiveness and misperceptions of dynamic complexity. I study 8 cases to identify the mechanisms that link such intervening variables with capabilities, institutions and learning in order to trace the vicious and virtuous cycles proposed by the analytical model.

With this multidisciplinary research I expect to contribute to the process of building a new perspective to development theories and practices. I believe an approach centered on learning processes that go beyond the human mind and intentionality may be the key for understanding the dynamics of development in terms of how capabilities and institutions evolve. Moreover, I intend to produce practical implications for public policies, overall for those in which the solutions focused on incentives and capabilities have been failing. Rather than the usual responses of contractual incentives and innumerable attempts of “empowering” local project leaders and populations, the approach I will present in the following chapters inquires how individuals, organizations and societies deal with changing circumstances and learn by trails and errors over time. The possible identification of patterns that block learning may be a relevant step for the development of new solutions towards the path of prosperity.

## **2. The Unexplored Role of Adaptive Learning in Political Economy**

Re-inaugurating the debate on the political economy of development, North and Thomas (1973) had an influential insight about how the variables we usually consider as explanatory of economic growth are not its causes, since they are growth itself. In fact, thinking of private investment, public expenditures, level of education or health care as causes of economic or social development is redundant, because they are part of development measures, such as Gross Domestic Product and the Human Development Index. Moreover, studying investment and capacity building as relevant factors of development is necessary but not sufficient, because how investment decisions are made and improved, as well as how capabilities can be built in underdeveloped regions are questions that remain unanswered.

New Institutionalism is the mainstream answer to these questions in the academy, both in Politics and Economics, as well as in Public Policy, as seen in projects managed by multilateral organizations such as the World Bank, the United Nations and the International Monetary Fund. There is a settled belief that well designed institutions are able to provide incentives that will guide different societies to prosperity, even with the evidence of the contrary exposed by the challenges faced by state building and local development projects. It is not my intention to make a frontal critique to these ideas and efforts, as I too share such beliefs to some extent, but why institutions don't produce the same satisfactory outcomes in distinct places and situations is an inevitable question.

While the recent literature in Social Sciences seems mostly focused on how incentives and constraints shape human behavior, there is an implicit and yet unexplored role for adaptive learning that may complement the approaches that explain how ideas, institutions and interests embed agency. More than the static influence of the “rules of the game” driving decisions, we should try to grasp the dynamics of the process of learning, decision after decision, which consolidates our experiences into capabilities and institutions. This research will take adaptive learning as a fundamental process for understanding social change within the political economy of development. This chapter examines to what extent the literature on Political Economy has been focusing on institutional incentives and constraints, leaving the process of learning disregarded or at best implicitly considered. While here I show the unexplored avenue in which this research intends to be a contribution, the next chapter will be about the interdisciplinary concept of learning on which I will build my hypotheses.

The following section starts with a discussion on the approaches based on interests and culture and how they are still limited to explanations about how political and economic choices are framed. The second section keeps the same argument for the approaches of political economy based on institutions. Section three, as an attempt to move beyond a theory of choice, will extend this inquiry along the institutional path in order to understand to what extent the literature explores the concept of learning within the dynamics of institutional change. I will make the argument that when political scientists borrowed the concept of path dependence from the



literature on increasing returns they emphasized the aspects related to costs and coordination and added the perspective of power, giving much less attention to the process of learning. Finally, I will discuss the Varieties of Capitalism framework as a systemic approach for studying complementarities between institutions that inspires a general hypothesis about the political economy of development in which adaptive learning plays a fundamental role.

## **2.1. Political Economy, Institutions and Learning**

Hall (1997) presents an insightful summary of academic efforts in the analysis of the political economy that are based on material interests, institutions and ideas. He posits that scholars explain how interests motivate individuals and groups, who articulate coalitions to produce different patterns of economic policies, as well as how these policies affect the interests of groups in the other way around. He also discusses how ideas are taken either as complementary to interests or as the preeminent cause of public policy design and strategy selection by firms. He argues that even for those who assign causal primacy to ideas, by and large its effective influence is only realized when they are institutionalized or embedded in specific social contexts.

For Hall, the institutions-oriented approach can integrate the positive political economy of interests and the cultural perspective of ideas, for institutions theory is not grounded only on rational choice models, but also on cultural embeddedness

and historical path dependence<sup>7</sup>. In fact, the explanatory power of institutions theory is rooted in its wide range of applications, enabling the integration of studies in Economics, Politics, Sociology and History, to name a few. However, it seems that from the rules of rational-choice games to the historically constituted social fields, the whole spectrum of institutional approaches is mostly focused in how incentives and constraints shape human behavior. Even when a historical component is added to interests, as in Krasner (2000) for example, or culture is the fundamental explanatory variable, as seen in Fligstein (1996), the emphasis rests upon incentives and constraints framing political and economic decisions.

Analyzing tariffs levels, trade proportions and regional trading patterns as indicators of economic openness, Krasner (2000) confirms the relevance of the hegemonic leading power to support free international trade. Nevertheless, he realized that Great Britain and the United States have both been prevented from making policy amendments in line with state interests at some point, delaying the expected pattern. British bankers were still encouraging open trade policies long after the “star had began to fall”. Congressional committees were still giving protection to import-competing industries after the First World War, when the United States emerged as an economic power ready to dominate the international market. Krasner had to make a historical amendment to the argument in his conclusion, because political and economic agents were not only motivated by power and interests, but also constrained by their own institutionalized past decisions.

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<sup>7</sup> Hall (1997), p. 191.

Fligstein (1996) argues that the lack of a social structure to control competition and avoid predatory practices explains businesses failures better than a lack of resources or capabilities. In order to illustrate the importance of a “stable conception of control”, he presents the example of the Japanese *keiretsu*. Fligstein points out that in these diversified business groups firms cooperate purchasing goods and services from each other, supporting each other in hard times and taking advantage of the close relationships with banks owned by the same holdings they take part. The notion that cooperating within the *keiretsu* is a “reasonable action” is nothing else than a cultural constraint that frames individual and groups behavior, either simply by imitation or based on expectations formed by identities.

Even though explained by very distinct influences upon human behavior, Fligstein’s Japanese firms and Krasner’s British bankers and American congress members respond to incentives and constraints imposed by their explanatory variables, respectively culture and interests. However, one question that is not part of Krasner’s scope is how those bankers and congress members would be able to respond promptly to changing circumstances. What blocked the learning mechanisms that would give them the signs, bargain after bargain, to change their political strategies? This question is not about to which direction their institutionalized past decisions would lead their actions with incentives or constraints, but why they didn’t learn they should change strategies from the feedback signs of the experienced bargaining. One interesting hypothesis to be

explored here would be that the institutional path dependence effect, rather than constraining strategies to the wrong direction, operated to weaken the learning process that would empower agency to better deal with changing circumstances.

While in Krasner's example the concern would be about the failure of learning mechanisms, Fligstein makes us inquire how these mechanisms work. How did those Japanese firms build trust as a fundamental business principle? Did they help each other, crisis after crisis, building practices of cooperation with encouraging payoffs? Rather than taking the social structure as a frame for firm's decisions, one can argue that the importance of the *keiretsu* stable conception of control is to allow learning from experiencing the principle of trust, reinforcing such business practices through time, empowering firms to cooperate and get the most from threats and opportunities that emerge during the hard times.

Krasner and Fligstein help illustrate not only the unexplored process of learning within political and economic contexts, but also Hall's argument on the relevance of institutionalized interests and ideas intertwined in cultural and historical aspects of the political economy. Interests and trust turned into formal and informal institutions, such as laws, contracts and practices, framing the behavior of individuals and organizations in the USA, England and Japan throughout history. When Hall (1997) turns to institutional-oriented approaches, one of his observations is that some of the most exciting conceptual developments in the political economy field are taking place at the boundaries of the institutional approach. He points out that the research on institutions is moving beyond the

conventional economic analysis that considered developed societies institutionally homogenous, stressing the need of a focus shift toward the socioeconomic and political variables that underpin institutional change. Following his advice on the promising path of institutional analysis, in the next sections I will explore the literature on institutions and institutional change in order to find the process of adaptive learning I'm looking for.

## **2.2. From a Theory of Choice to a Theory of Change**

According to North (1990), institutions are rules and procedures that establish stable structures for political and economic relations, allowing individuals and organizations to accomplish their potential according to their goals. If the economy is driven by productive investments, an institutional environment that reduces uncertainty encourages relationships between economic agents and creates conditions for the commitment of resources in the long term. In its turn, the provision of public goods depends on the implementation of policies, programs and projects. In the presence of an institutional environment in which rights and duties are accomplished and in which access to information is guaranteed by transparency and accountability, agents have incentives to use "voice" channels and become less susceptible to arbitrariness in elections and public management, thereby improving the performance of public organizations and policies. Productive investment and public policies are products of human action, of choices of individuals and organizations influenced by costs and benefits ratios established by institutions. As stated by North, his argument is built

on a theory of human behavior combined with a theory of transaction costs, in which “institutions define and limit the set of choices of individuals”<sup>8</sup>.

I engage with North’s definition to make my point because of his clarity and influence. He made the empirical work of researchers a lot easier with his distinct categories for institutions and organizations, as well as for formal and informal institutions<sup>9</sup>. I argued in the previous section that cultural framing and historical path dependence can also be taken as incentives and constraints that influence individual and organizational behavior, but I think North is more explicit than anyone else in institutional theory advocating for a kind of political economy based on a theory of choice<sup>10</sup>. Yet, the contribution this research intends to make is based on the proposition that we still need to find a perspective of political economy based on a theory of social change. Can institutions explain change rather than only choices? Analyzing the following empirical works on the seminal concept of “credible commitments” may shed light on this question.

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<sup>8</sup> North (1990), p. 4.

<sup>9</sup> Other influential scholars argue for the use of a wider concept of institutions. For example, Evans and Chang (2000), studying the case of South Korea, claim that the developmental state is the best “institutional instrument” for less developed nations to catch up economic growth. In his famous comparative study in Italy, Putnam (2007) argues that more than the rules of the game, “institutions are devices for achieving purposes” through governmental action. In *Varieties of Capitalism* the concept of institutions follows this expansive trend, as seen in Schneider (2013), for instance. I agree with Schneider (2013:6) when he points out that “institutions and organizations require equal treatment in institutional analysis”, but I think the precision of North’s definition is empirically powerful for controlling variables in comparative analysis, giving less room for “concept stretching”, in the sense explained by Sartori (1970, 2009).

<sup>10</sup> Hall & Taylor (1996), for instance, named “Rational Choice Institutionalism” the school that emphasizes property rights and transaction costs as seen in North. Besides this “economic” approach, they identify as “Sociological Institutionalism” the one that defines institutions not only as rules, but also as symbols, cognitive schemas and moral standards that guide human action; and “Historical Institutionalism” as the approach that considers institutions as part of a chain of causes and effects that takes into account other factors such as the diffusion of ideas and socio-economic development.

North and Weingast (1989) narrate the story of the Glorious Revolution, explaining how institutional change altered incentives of governmental agents to create credible commitments regarding property rights, while the Crown became the “king in Parliament”. They explain that the victorious parliamentary interests led to relevant institutional changes that enhanced the predictability of government decisions. As also presented in North’s theory, the conclusion is that the ability to engage in secure contracting across time and space is a necessary condition for the creation of modern economies.

The article fulfils the promise of explaining how institutions controlled the power of the Crown over fiscal, legislative and judicial matters, while balancing the power of the Parliament, making credible the government’s commitment of honouring its agreements. North and Weingast also present convincing evidences that private capital markets flourished with the stability of the public power in its commitment to secure property rights. They call attention to the remarkable increase of banking operations, including the trading of securities, discounted bills and notes, as well as the fall of private interest rates. Based on these evidences, they observe that the growth of the financial market “appears to have financed a large variety of business activities”<sup>11</sup>, constituting a necessary force of the economic expansion of that time.

The empirical analysis is clear explaining why economic growth was produced: a set of institutions constrained government arbitrariness, creating a stable structure

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<sup>11</sup> North and Weingast (1989), p. 828.

with incentives to the public and private financial sectors. The growth of these sectors combined with the government's enforcement of property rights created incentives for entrepreneurs to invest. Albeit an important argument, the dynamics of economic development is not in the scope of such explanation, for describing the economic process from incentive to incentive, they leave the complexity of continuous learning, at best, implicit. How did the new banks access knowledge and grow over time? How did they develop new financial instruments? How did each new bank or business face opportunities and threats while learning with success or failure? How did they improve practices, products and markets? In order to explain economic development, we should study how institutions were able to allow learning from experimentation. Isn't the power of credible commitments in allowing adaptive learning in the long run, rather than just creating incentives for economic performance?

Weingast (1995) goes further with the argument of credible commitments not only with the case of England, but also with more recent examples about the United States and China. His main question is how market-preserving federalism can be self-enforcing, but I'd like to highlight two aspects of his article that can start a dialogue with the idea of learning closer to the realm of politics. The first is the presentation of the economic effects of federalism as a process of political competition. Here, again, incentives shape decisions in the subnational level, where policy makers will try to attract economic activities with different mixes of taxation, public goods, social protection, etc. Observing the dynamism of the decision-making explanation one may foresee a process of adaptive learning, in



which policies are improved through time. In this sense, besides the role of balancing power through incentives, power decentralization is also a source of institutional and policy experimentation.

The second point brings us back to the seventeenth century in England. Weingast explains the political disputes between Whigs and Tories at that time as a problem of coordination. Their marked divisions prevented the formation of shared beliefs about the role of the state, the limit of sovereign power, citizen duties, and other economic and political rights. The Revolution led to the construction of new consensus and institutions, such as the Declaration of Rights, where both parties negotiated the limits of the sovereign action. This process resulted in a new set of shared beliefs, recorded in formal institutions that would function as coordination devices. Weingast's explanation can be interpreted as an interesting learning feedback, in which Whigs and Tories learned from political practices, adapting their negotiations according to changing circumstances, and consolidating the lessons learned into new principles in shared beliefs.

In both works, either as incentives for business investments or coordination devices for political disputes, institutions operate as credible commitments that reduce uncertainties for actors who need to make choices based on preferences and beliefs. However, the process I'm trying to emphasize is the one that explains changes, rather than choices. This process is implicit in Weingast's subnational competition as well as in his explanation of Whigs and Tories political disputes, if we locate such choices in time, taking changes in preferences and beliefs

historically. It is also implicit in the dimension of time of “secure contracting” in England, in which firms learn and interpret, deal after deal, the incentives provided. This implicit learning process may help us explain the feedback mechanisms that change preferences and beliefs beyond the unidirectional causality of credible commitments that produce better choices. Institutional analysis has long incorporated the reinforcing feedbacks and the dimension of time to explain not only when but also why and how change emerges, a literature explored in the next section.

### **2.3. Learning and Path Dependence in Institutional Change**

The debate about institutional change in political economy has been built on a critique of the reductionism of unidirectional causality as well as upon an inquiry on the possibilities and mechanisms of agency in order to promote change. As argued by March and Olsen (1984), institutions seem to be neither only reflections of environmental forces nor neutral arenas for rational strategies driven by exogenous preferences: human actions, social context and institutions work upon each other in complex and interactive processes. In that influential paper, March and Olsen stimulated the discussion about causality with a critique of the functionalist idea of historical efficiency that reduces complexity to short-term linear problems of optimization.

North himself admits that while his initial studies placed institutions in the center of economics as incentives structures, they disregarded “the way humans

understand and act upon” societal change<sup>12</sup>. In fact, the historical functionalism of North & Thomas (1973) is explicit in their explanation of the rise of the Western World as a product of the economic efficiency of institutional arrangements of property rights driven by relative prices. Even though his later works would include political and social aspects, such as the relevance of organizational interests in the process of institutional change and the role of cultural factors present in informal institutions as sources of path dependence, the framework is still pretty much based on efficiency: institutions are rules that establish stable structures for political and economic relations, allowing choices towards the best possible strategies according to expected payoffs. It seems that the symbolic world built by human relations is not yet part of such models and we still have a long way to understand how we learn from others and ours payoffs, how learning changes beliefs and preferences historically, and how it affects institutional change. In the terms used by North is his self-criticism, it may be the case that while advancing in the explanation of the processes of change we still need to grasp how humans interpret and understand such processes.

My suggestion is that one of the missing parts of this puzzle is the feedback process we call “learning”. When political scientists borrowed from the literature on increasing returns the concept of path dependence as reinforcing feedbacks that can lock in certain political and social patterns historically, they emphasized the aspects related to costs and coordination, and added the perspective of power, giving much less attention to the process of learning. Moreover, when they discuss

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<sup>12</sup> North (2005), preface.

learning in political economy it is usually incorporated in stocks of knowledge related to human capital or social capacities, rather than described as a dynamic process of change. “Learning effects” are taken as incentives or constraints that frame behavior just like the institutionalized interests and ideas discussed previously. Scholars agree that knowledge can provide better choices, but we know little about the learning processes that build knowledge in terms of capabilities and institutions. In other words, we’ve been discussing static stocks and their influence upon individual and organizational choices but should go further on the dynamic flows that characterize the patterns of learning feedbacks in institutional and social change. It is through the process of learning in the face of continuous change that such political and social stocks evolve, a process of adaptation that can either lock us in less developed patterns or unlock the path towards prosperity.

The main reference on path dependence for North (1990) and Pierson (2004), two of the most frequently cited works in institutional change, was the literature on increasing returns summarized by Arthur (1994). He presents four generic sources of self-reinforcement mechanisms in the economy of technology: large set-up or fixed costs (the advantage of the lower marginal cost of a settled technology over the entrant); learning effects (knowledge about the settled technology constrains the adoption of the entrant); coordination effects (advantage of going along with other adopters of the settled technology); and expectations (long duration of certain technology enhances the expectation of its prevalence in the future)<sup>13</sup>.

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<sup>13</sup> Arthur (1994), p. 112.

Arthur also explains that as consequences of self-reinforcing mechanisms the market systems in which such technologies compete will admit inefficiencies and multiple equilibria. Of which technology the path will be dependent is indeterminate, because inferior technologies can lock the economy in less efficient solutions simply because of an earlier start. He explains path dependence as the influence of the early history of market shares, including small events and chance circumstances, on the solution that prevails.

North (1990) extends Arthur's argument to the problem of institutional change<sup>14</sup> to present a theory of transaction costs of imperfect markets as a new source of path dependence. Consider taxation systems in less developed economies as examples of patterns locked in inefficient solutions. Albeit several efforts are made in order to advance for a better taxation system, one of the important institutional improvements for doing business, the *status quo* is reinforced by the large cost of implementation; by the knowledge accumulated about the settled system; by coordination effects such as the complementarities between federal, state and municipal taxation laws that reinforce each other; and by the expectations of policy makers and entrepreneurs who make cash flow projections based on the established system. Politicians, public servants, businesspeople, accountants, lawyers, citizens and any individuals and organizations involved in such system are constrained by what they and others know, expect and weigh in terms of costs and benefits. Moreover, they are constrained by the "mental

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<sup>14</sup> North (1990), p. 94.

constructs” they build to interpret reality based on fragmentary and imperfect feedbacks of information.

Pierson (2004) also recognizes the broad applicability of Arthur’s arguments and agrees with North on transferring such technological features to the institutional environment. He places politics in time, pointing out the importance of the identification of self-reinforcing dynamics, timing and sequencing for examining historical phenomena, highlighting four features that make path dependence prevalent in politics: collective action, institutional density, complexity and political authority. He explains how Arthur’s self-reinforcing dynamics are associated with the collective nature of politics, “especially high start-up costs, coordination effects and adaptive expectations”<sup>15</sup>, because considerable resources are mobilized in organizing groups and the consequence of one’s action is highly dependent upon the actual and expected actions of others. He also follows North in the argument that “the interdependent web of an institutional matrix produces massive increasing returns”<sup>16</sup> and in the explanation of how the intrinsic complexity and opacity of politics reinforce biased mental models of reality. At fourth place, Pierson notices that the list offered by economists doesn’t exhaust the possibilities of sources of feedback and suggests that political authority is also self-reinforcing, insofar the employment of power can produce asymmetries in favor of the rulers that shape the historical path.

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<sup>15</sup> Pierson (2004), p. 34.

<sup>16</sup> North (1990), p. 95.

Pierson (2004) makes sure to point out that path dependence doesn't freeze structure into historical determinism, but rather places history into a trajectory whose boundaries can be changed. He explains that in path dependent processes cause and effect are connected by a remembered history that starts with a "critical juncture" and develops through positive feedbacks. These feedbacks reinforce the initial path until the next event capable to create a new trajectory. Such events may be disruptive, but even when small they can have amplified outcomes, depending on when and for how long they take place. In this sense, Pierson points out that political space and social capacity are features that make timing and sequencing relevant in path dependent processes. Once the *locus* of power is occupied, oppositionists face a higher cost in their task towards political change. Depending on the repertoire of social capacities available when opportunities emerge, agency can be empowered to produce or avoid change.

In sum, for North there are two forces that shape the path of institutional change: increasing returns and transaction costs. He explains Arthur's arguments with institutions in the same fashion I attempted to exemplify with taxation systems; and he adds, as a second source of path dependence, the transaction costs of imperfect information that shape the subjective models actors use to make decisions. Pierson, in his turn, follows Arthur and North, and adds political power as a new source of self-reinforcement.

The point North and Pierson diverge, however, is on the subject of learning. North (1990) explains adaptive efficiency as trials, experiments and innovations

encouraged by institutions; and also makes the clear statement that we should start to focus our attention on human learning, from individual experimentation to cumulative experiences of past generations in our society<sup>17</sup>. North (2005) develops his previous argument about “subjective models” explaining economic change as a process shaped by perceptions about reality that influence shared beliefs on which institutions are constructed. He adds learning in his model as an incremental process, filtered by belief systems, that determines the perceived payoffs and can also affect back such beliefs. For North, learning is the process through which mental models evolve according to feedbacks derived from experience<sup>18</sup>.

North makes several statements about the relevance of learning for understanding economic change, but it seems he still gives primacy to institutions in his model, for the growth of knowledge is dependent on complementary institutions<sup>19</sup> and institutions determine who are the entrepreneurs whose choice matter in the process of change<sup>20</sup>. When he presents the cases of the Western World and the Soviet Union the set of explanatory variables of success and failure is broader, including demographic change and the stock of knowledge, but learning is only briefly discussed as a product of the Christian beliefs of the Middle Ages that led to adaptations favorable to economic growth.

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<sup>17</sup> North (2005), Preface.

<sup>18</sup> North (2005), p. 25.

<sup>19</sup> North (2005), p. 99.

<sup>20</sup> North (2005), p. 6.



Unlike North, Pierson sustains that “learning is very difficult and cannot be assumed to occur”<sup>21</sup> in politics, because the political actor engages only sporadically in political issues that are characterized by the opacity of complex causal chains, what makes trial and error processes far from automatic. He points out the importance of the investigation of the political circumstances in which learning processes are effective, but sees little reason to take learning as a “reliable tool of institutional enhancement in politics”<sup>22</sup>. It is important noticing, however, that North’s object of study is not restricted to the realm of economics, but rather includes the timeline and complexity of politics mentioned by Pierson within a wide range of interdisciplinary factors.

If we look at Pierson’s political space and social capacities as accesses to ways of learning that would otherwise be closed, we may conclude that better choices, changes or the reinforcement of the *status quo* are not just matters of stocks of power, knowledge or social capital. When a small firm becomes a member of an association, for instance, it gets more than being part of an influential lobby in the polity, reports with sectorial analysis or a notebook with important connections; it gets access to learning from the experience with politics, from using the available data in its own business and from continuous interaction with the new available network. In this sense, back to the example of taxation in less developed economies, learning may empower the firm to unlock the economy from the path dependent pattern of the settled system. First, learning the technical aspects of the new fiscal system from the shared knowledge of other members of the association,

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<sup>21</sup> Pierson (2004), p. 38.

<sup>22</sup> Pierson (2004), p. 126.

the small firm will reduce the advantage of the old system's "learning effects". Second, learning the political processes within the association's political space, e.g. bargaining in the parliament, the firm will be empowered as a political agent for institutional change. As a consequence, knowing how to change the rules and how to mobilize forces in order to do so reduces the relative advantage provided by set-up costs. It is through the same process of learning that public spheres, including policy makers and politicians, and private agents, such as accountants and lawyers, will disarticulate and rearticulate coordination around the new taxation system. Then, more broadly and less intentionally, the firm will be part of a social process of learning new practices, such as those related to an eventual reduction of tax evasion or bribing, and expectations will turn to a new direction.

The ideas of sequencing and timing are insightful *per se* if one wishes to move from static to dynamic modeling in order to understand institutional change. They provide a somewhat concrete notion of process, step by step, and bring about the subject of opportunity, an important concept for the matter of agency in various fields, from business strategy to social movements. However, it seems an important piece of such dynamics will be missing if we don't take learning feedbacks into account, either as a source of path dependence or for the empowerment of agents for the opportunities of change. In this sense, identifying the mechanisms of reproduction of positive feedbacks, including the process of learning, is important not only for clarifying path dependent processes intertwined in social complexity, but also for understanding the possibilities of trajectory changing.

The possibility of agency for institutional change is one of the main questions of Mahoney and Thelen (2010), whose theoretical starting point is the argument that sociological, rational-choice and historical institutionalisms explain the persistence of institutions as well as exogenous causes of change, but do not provide a model that comprehend endogeneity. Indeed, endogenous forces are particularly important if we decide to study institutional change as complex phenomena, taking multi-causality and reinforcement feedbacks as usual characteristics of political systems. Like North and Pierson, Mahoney and Thelen explore the complementary effects of institutions and processes of change, but they set aside the subject of reinforcement to focus on institutions as devices of power distribution that “animate” change. They explain the incremental processes through which institutions evolve supplementing this power-distributional approach with compliance as an intervening variable, arguing that institutional change occurs upon opportunities opened by ambiguities about rules and their enforcement. The model details how the veto possibilities of the political context and the level of discretion in interpretation and enforcement of institutions are related to different modes of change and how they shape the type of agents and their strategies.

Even though there’s still a primacy of institutions, insofar they bring within the allocation of power and the possibilities of interpretation for change, Mahoney and Thelen’s explanation of the modification of the meanings given by agents is a learning process at work: “as the meaning and enactment of an institution change,

so too may actors preferences”<sup>23</sup>. In fact, changes of such meanings affect agent’s preferences in a process comparable to North’s adaptation of mental models, turning compliance into a product of learning from experiencing the institutions that may be the subject of change. In this sense, learning may come back to the picture as a feedback process that can be both the source of reinforcement of the established pattern, likewise Arthur’s “learning effects”, or the source of agency that produces change.

The ideas presented in this section bring institutional analysis beyond the reductionism of unidirectional causality and deal with agency taking into account the opacity imposed by the limits of human cognition. While North and Pierson advance the discussion on the sources of increasing returns to the realms of political economy and politics, Mahoney and Thelen move the focus to explain change and unlock agency in path dependent institutional processes. Each of their crucial contributions brings implicit or yet unexplored new questions about the learning processes attached to the complex dynamics of institutional change.

I attempted to make a differentiation between stocks and flows in order to unveil a fundamental process of learning that complements Pierson’s argument about reinforcement feedbacks, timing and sequencing. While higher stocks of power and social capital are likely to have strong correlations with developed societies, they will tell us little about the prospects of the less developed. It is the flow through which such stocks are produced that really indicates the path towards

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<sup>23</sup> Mahoney & Thelen (2010), p. 14.

prosperity. I also argued that learning from experience is the source of the evolving meanings found by Mahoney and Thelen's agents within processes of institutional change. Nevertheless, albeit still emphasizing aspects of incentives built in institutional structures, it is North who explicitly points out the importance of learning in the process of change of the political economy, opening a fruitful avenue for research yet to be explored. Moreover, he presents the process of economic change as complex in terms of causality and non-ergodic in its continuous novel change, softening the determinism eventually seen in the path dependence of institutional change. In this sense, learning is part of a feedback that breaks unidirectional causality and may be the key that unlocks agency for institutional development.

Understanding the political economy of development as complex phenomena, translating reality into cycles of equilibrium or reinforcement, either virtuous or vicious, instead of linear unidirectional cause and effect relations, is a crucial step to grasp the power of learning processes of adaptation. When Hall (1997) locates institutions in the center of a possible integration among approaches in the field of political economy, as discussed previously, he also observes the need of a certain amount of complexity to deal with an expanded range of variables. Likewise the scholars discussed in this section, Hall and Soskice (2001) focus on institutions and their complementarities, pointing out contexts in which institutions increase the returns from each other, introducing Varieties of Capitalism as a relational approach that aggregates perspectives and variables from Economics, Politics,

Sociology and Business into a model that stands up to complexity in a very interesting and fruitful manner.

#### **2.4. Development and Learning with Institutional Complementarities**

Hall & Soskice (2001) present a powerful agent based framework, built on assumptions and insights of the institutions theory, with two ideal types of political economies: liberal (LME) and coordinated (CME) market economy. The firm is the center of the model, but they give special attention to internal and external relationships established by firms with employees, unions, associations, clients, suppliers, governments and stakeholders in general to understand strategic interactions and its outcomes. The framework allows empirical studies on interests bargaining policy design, such as small and medium size firms demanding flexibility increase for industrial relations in Germany during the 80's (Thelen and Kume, 2003); ideas influencing institutional diffusion, as pointed out by Vogel (2003) to explain how Germany was more infiltrated by the views of international organizations than Japan; and incentives established by formal institutions, such as how financial regulation shapes shareholder markets in liberal economies (Hall and Soskice, 2001). Furthermore, the approach is helpful for explaining how institutions complement each other. For instance, in the United States market oriented regulation, flexible industrial relations and an equity based financial market are related to radical innovation and high tech; while in Germany available long-term credit – the so-called “patient capital” –, strong labor unions and business associations are related to incremental innovation and manufacturing.

Institutions are essential variables in this model because they support the relationships firms establish to solve coordination problems. Hall and Soskice explain that institutions provide the capacities for information exchanging, behavior monitoring and sanctioning defections relevant to cooperation, improving the relations between agents. In this sense, they point out that while in LMEs competitive market arrangements and hierarchies coordinate firm's performance, in CMEs firms coordinate their activities with non-market relations, highlighting the role of networks as efforts to secure cooperative outcomes of strategic interactions among agents.

Vogel (2003) posits that even when considerable variation across sectors and firms is observed, the distinction between CMEs (which he calls "organized" instead of coordinated) and LMEs remains significant. The empirical question behind this claim is whether size, age and sector of firms explain business strategy, funding and innovation better than the coordination policies used to distinguish developed economies. A start-up company, for example, usually seeks market share before reaching its break-even point, when it will begin making profits. When they are new businesses and don't have assets to give as collaterals for debt contracts, start-ups look for partners in order to finance investments with private equity. Eventually, these companies will be trying to launch a patent pending product or service. One can make similar claims for age and sector, arguing that such preferences can be present both in Germany and United States.

The critique above is not for the framework itself, it is rather motivated by a good skepticism about the distinctions between developed economies. United States, Germany, Japan, and all the developed nations mentioned by Hall & Soskice are market economies that work well. Comparing to the developing world, they have systems of prices that provide reliable enough information for businesses decisions, processes of competition that enhance productivity and innovation, not to mention credible commitments about property rights. Networks that enhance information exchanging, behavior monitoring and cheaters sanctioning are also present in both LMEs and CMEs, even though in LMEs not necessarily as a product of intentional design. Maybe the effective value of the so-called coordinated oriented policies relies on the contribution they provide to make the systems of price and competition work as learning processes. To what extent each variety of capitalism enhances or destroys market relations, allowing or blocking adaptive learning for individuals and organizations? Moreover, can this framework help us understand the links between political economies, learning processes and levels of development?

Studying Chile, Brazil, Argentina, Colombia e Mexico, Schneider (2013) expands the Varieties of Capitalism framework introducing the “hierarchical” ideal type. He notices that most of the typologies of capitalist systems focus on inductive clustering of developed economies<sup>24</sup>, offering a classification based on mechanisms of resources allocation. For him, while business decisions are mostly

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<sup>24</sup> For example, Coats (2000) adds Japan and Schmidt (2002) adds France and Italy in a third state-led category of capitalism; and Kitschelt et al. (1999) divide CMEs countries in labor corporatists (Scandinavia), sector-coordinated (Rhine) and group-coordinated (Japan and Korea).



based on market relations in LMEs and bargaining in CMEs, in HMEs they are implemented top-down<sup>25</sup>. He persuasively explains how diversified business groups, multinational corporations, atomized labor relations and low skills mutually reinforce each other, maintaining the hierarchical relations between and within firms. Schneider points out that the informality, high turnover, low unions density and over regulation of the labor market in the region discourage investments in skills for both employers and employees, in a kind of coordination locked in the inefficient equilibrium he calls “low skill trap”.

In order to make a connection to the literature about institutional change and the subject of learning, one may notice that the complementarities pointed out by Schneider make development incremental and path dependent, rather than abrupt, and help us understand the “trap” in which Latin America is locked in as a pattern in complexity, rather than a positive unidirectional causal mechanism. Second, Schneider is interested in how businesses engage in politics rather than just in the influence they have. This approach is important to help us move the focus of our research from the incentives provided to agents by stocks of power to the process throughout power is produced and maintained. Hence, as explained by Schneider, Latin American business groups are less interested in direct political action towards policy making related to trade, FDI, education or R&D, turning themselves into agents of “quite politics” that produce barriers for new entrants in order to keep their political space reserved. Schneider’s account of the relations

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<sup>25</sup> Besides the United States as the representative case of LME, Germany as CME and Chile as HME, Schneider points out Japan as the example of a fourth type of capitalism, the Network Market Economy (NME), in which the main allocative principle would be “trust”.

between business groups and the state in the region as rent seeking, lobbying or “Leviathan shareholder minority” inspires the argument that the non-market relations that were expected to coordinate and improve economic performance turns into harmful practices that block the diffusion of the learning benefits of networks. Information flows only for groups in collusion, monitoring and sanctioning are selective, and businesspeople may work more hours per day discussing strategies for lobbying and rent seeking than for marketing and competition. The adaptive process at work here is a selective and predatory trap that keeps the agents interested in change out of the game.

As an effort for searching patterns produced by institutional complementarities within reinforcement feedbacks, the Varieties of Capitalism approach is an interesting response to the critique of the literature on institutional change about unidirectional causality. Locating economic and political agents in the center of the framework, scholars of this approach also deal with the problem of agency within institutional change. Schneider’s empirical application of the framework, in particular, inspires a series of questions for researchers interested in the political economy of Latin America and the rest of the developing world. Are the less developed regions locked in path dependent patterns? What are the composite processes of such patterns in terms of capabilities and institutions? Which processes can unlock the development pattern? These questions are the starting point of my empirical work.

On the other hand, in *Varieties of Capitalism* institutional complementarities are still taken as all kinds of sources of reinforcement for path dependence, except as learning processes. Furthermore, as Arthur (1994) points out, the theme of exit from locked-in less efficient states runs through the literature on development economics as studies about synergies and linkages between industries and policies mostly produced by coordination mechanisms. He explains that the “exit from an inferior equilibrium in economics depends very much on the source of the self-reinforcing mechanism”: advantages of learning effects and fixed costs are less reversible or transferable to alternative states than the advantages seen where coordination is the source of lock-in<sup>26</sup>.

In fact, there is an extensive literature on the political economy of development that has been exploring the coordinated strategies nations must implement to achieve higher levels of wellbeing. Within efforts to improve institutions and build capacity, private and public projects have been managed trying to turn human capital and material goods into a reasonably distributed wealth. However, in the search for explanatory variables and strategies to implement prescribed policies, development theory overlooks how individuals and organizations respond in face of changing circumstances. This response is certainly influenced by institutions, human capital and other available resources, but what seems to be missing is the learning factor that unlocks the potential benefits of these variables throughout history.

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<sup>26</sup> Arthur (1994), p. 118.

The simple effort to define development as a specific goal is based on the determinist assumption of a developed status achievable in the future, as well as leads to reductionist conclusions and prescriptions for accelerating the catch up process with unidirectional and short-term causal relations. The idea that it is possible to grasp the complexity of change understanding and describing its causal relations into laws and structures may be replaced by the search for the patterns through which institutions and knowledge are historically built as a cumulative process of experimentation. In this sense, rather than focusing on designing institutions, policies and projects, we should study the learning mechanisms that allow continuous improvement in these matters. The general hypotheses I intend to develop from now on is that *learning* is a source of path dependence of the underdevelopment pattern and that there are *adaptive learning types* that unlock prosperous development.

### **3. Adaptive Learning**

The previous chapter makes the proposition that there is an unexplored role for adaptive learning in the subfield of Political Economy of Development. It discussed a selected literature with emphasis on institutions in order to present three main arguments. The first was that we should move from a theory of choice, based on incentives and constraints, to an approach that takes into account the dynamics and complexity of social change. The second was that when we study the reinforcement feedbacks that produce such complexity the focus is on costs, coordination and power, leaving aside the process of learning or considering it strictly as stocks of knowledge that frame choices. The third argument was that these learning processes might help explain path dependent patterns such as seen in developing and underdeveloped societies.

These arguments leave the questions of what is learning and what would be a learning approach in the context of development. This chapter is an attempt to answer these questions. I will study an interdisciplinary literature in order to develop the general hypothesis that learning is a source of path dependence of the underdevelopment pattern and that there are learning types that unlock prosperous development. This review will help with the accomplishment of two main goals. The first is the definition of a grounded concept of learning that can be studied empirically. The second is to subsidize the formulation of an analytical model that takes into account the complexity of the problem of development and society as a learning system.

The following section presents a perspective about development as a process of learning and adaptation. I suggest an evolutionary approach with emphasis on organizational learning as a step further the mainstream research on the primary causes of development. I will also review important references from different fields such as Psychology, Anthropology, Organizations and Economics in order to present a concept of learning beyond individual and disciplinary boundaries. I will argue that the concept of learning as “adaptive reorganization in complex systems”<sup>27</sup> connects distinct levels of analysis and time scales, allowing the study of the learning processes that generate capabilities and institutions as co-evolving subsystems of the development system. Section 3 will exemplify and clarify in what sense one may consider the production of social goods as a learning system.

### **3.1. Development as a Learning Process**

The search for the primary causes of economic growth and development produced convincing theories and empirical evidences for several possible explanatory variables, such as geography and natural resources<sup>28</sup>; human<sup>29</sup> and social capital<sup>30</sup>, institutions<sup>31</sup>, and so on, an inquiry that has been always pervaded by a passionate debate about the role of the state. The Cold War was the background of a dispute between the principles of the free market and the developmental state in

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<sup>27</sup> Hutchins (1995).

<sup>28</sup> Diamond (1999), Sachs (2012).

<sup>29</sup> Romer (1986), Lucas (1988), Gleaser et al (2004).

<sup>30</sup> Putnam (1993).

<sup>31</sup> North (1990), MacFarlan, Edison & Spatafora (2003), Acemoglu, Johnson & Robinson (2004).

Economics that was reopened for Politics and other fields when institutions and social capacities became part of the mainstream. Influenced by works such as North (1990) and Sen (1999), policy makers in multilateral organizations were convinced that institutions mattered and they should measure human development rather than simply calculate economic growth. In the academy, as explained by Doner and Schneider (2000) and Doner (2009), neoclassical economics expanded to New Institutional Economics (NIE) relaxing assumptions about perfect information and utility maximization, while the developmental state embraced institutions as fundamental variables in approaches such as the Varieties of Capitalism.

In the previous chapter I followed the path of institutional theory to make the argument that while moving from unidirectional causality to complexity as a product of reinforcement feedbacks, both NIE and Varieties of Capitalism still left implicit or unexplored the role of adaptive learning in development. This move opens the possibility of bringing back to the Political Economy of Development an evolutionary approach that has gained grounds in Economics mostly in studies on innovation, but could be taken as broadly as it used to be in the early days of Political Economy.

The evolutionary approach in Economics was organized in a theory in the seminal work of Nelson and Winter (1982). They study how the capabilities of firms evolve as a result of problem-solving efforts and random events, in a process of learning and adaptation in which such organizational “traits” are transmitted over

time. They present their evolutionary theory as a criticism to the neoclassical assumptions of equilibrium and rationality, interpreting the economy as a process of continuous change in contexts that are not completely familiar or perfectly understood to individuals and organizations. Dosi and Nelson (1994) state that the “behavioral foundations of evolutionary theories rest on learning processes involving imperfect adaptation and mistake-ridden discovery”<sup>32</sup>, explaining “learning” as a search to improve or uncover new technologies in terms of products and processes. Furthermore, influenced by Schumpeter’s idea of “creative destruction”, evolutionary theory takes capitalism as a process that “revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one”<sup>33</sup>, an engine whose impulse comes from new products, processes, markets and forms of industrial organization that the capitalist enterprise creates in order to get more profits with some sort of transitory monopoly. In this sense, more than products and processes, in economic change technologies and industrial structures co-evolve<sup>34</sup>.

More recently, Nelson (2008) made the point that Schumpeter and the early empirical works on evolutionary economics overlooked the institutional complexities of modern market economies. He argues that a satisfactory theory should see economic growth as “the result of the co-evolution of technologies, firm and industry structures, and supporting and governing institutions”, stating that the driving dynamics of the economy involves the interaction of these three

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<sup>32</sup> Dosi & Nelson (1994), p. 159.

<sup>33</sup> Schumpeter (1942), p. 83.

<sup>34</sup> Dosi & Nelson (1994), p. 161.



levels. He suggests that scholars should bring institutions to the umbrella of Evolutionary Economics to cover this blind spot in order to study the whole system that supports the dynamics of innovation. I see this claim as the point of convergence between the systemic approach of institutional complementarities, as discussed in NIE and Varieties of Capitalism, and the dynamics of the learning processes of Evolutionary Economics. Looking from the perspective of the Political Economy of Development, I suggest bringing to the center of our model the learning processes that power the co-evolution of capabilities and institutions. In this case, learning is more than R&D and the problem we study is broader than innovation systems.

The concept of development as a learning process has its foundations in the early days of Political Economy. Adam Smith's invisible hand was taken by a positivist economic theory to explain market equilibrium, but this metaphor is part of a broader tradition, as pointed out by Hayek (1960)<sup>35</sup>, that understands the power of spontaneous order in all human endeavors as a process of continuous imitation, trial, error and learning from experience, from which new institutions and practices emerge. Hayek states that we should "think of progress as a process of formation and modification of the human intellect, a process of adaptation and learning in which not only the possibilities known to us but also our values and desires continually change"<sup>36</sup>.

Hayek adds to this tradition an epistemology of complexity and an insight about

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<sup>35</sup> Hayek (1960), Chapter 4 – Freedom, Reason and Tradition.

<sup>36</sup> Hayek (1960), p. 37.

the use of knowledge in society that make experimentation the social learning mechanism *par excellence*. He argues (Hayek, 1967) that for complex phenomena, such as those studied by Social Sciences, the conception of “law” in the cause and effect sense of natural sciences is inappropriate. Such phenomena must be studied and explained as patterns that emerge under certain circumstances from the relations between the elements of a system, rather than by individual events. Hayek (1948) also states that as the main problems of society are related to rapid adaptation to changes in particular circumstances, we should leave the decisions to the people who are familiar with these circumstances, maximizing the chances that knowledge will be properly used. Based on the idea of adaptation in face of complexity, this is a strong argument in favor of decentralization and spontaneous order not only for market relations, but also for institutional and cultural change. In fact, he points out that the problem of the use of knowledge, which is not given to anyone in its totality, “is by no means peculiar to economics”, but rather “constitutes really the central theoretical problem of all social science”<sup>37</sup>.

Hayek’s epistemology encourages the adoption of development as a learning process to be studied by its composite processes rather than by explanatory variables in unidirectional causality. Instead of the primary causes we’ve been looking for, we should try to grasp the patterns of development as processes of fortune taming, of adapting in the face of changes and achieving goals through a decentralized learning process of trial and error. Rather than a state to be reached,

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<sup>37</sup> Hayek (1948), p. 88.

development may be the process of learning by which human organizations get ready to act when opportunities arise from the continuously changing environment.

I take this step back to Hayek's interpretation of the early days of Political Economy to clarify two important aspects of this research. The first is that the process of evolution in focus is not the mechanism of "natural selection" in which individuals and organizations compete to "survive", but rather the learning processes that generate capabilities and institutions that will support these individuals and organizations in the adventure of building prosperous societies. It is the fitness of learning types that matters here. The issue is neither just about stocks of knowledge operating as sources of path dependence of one technology over the other, nor stocks of human capital that increase productivity and produce growth. The subject I intend to observe is the dynamics of learning processes that produce such stocks and, moreover, the fitness of types of learning in certain environments and how they produce or slow down development.

The second aspect is the systemic character of complexity as discussed with the literature on NIE and Varieties of Capitalism. Nelson also made his point about the complementarities between technologies, industries and governing institutions, three subsystems of the innovation system in which not just firms but also policymakers are important actors. Hayek's broader approach inspires an even more extensive analytical division of subsystems that may go beyond the limits of the intentionality of private and public agents, including social and cultural traits

that are not necessarily products of human design. In this sense, development is an evolutionary process of adaptive learning in complexity.

### **3.2. The Learning Wave**

I argued previously that as learning is taken in Political Economy mostly as stocks of knowledge that frame agent's choices, we end up missing the dynamics of change that may be observed in learning as a process. While Evolutionary Economics is a step further from a theory of choice to a theory of change, it is still restricted to the realm of innovation systems in which learning is mostly a matter of improving technologies of products and processes. The previous section suggested that we should study development incorporating a broader evolutionary approach with emphasis on the learning processes that produce not just capabilities for individuals and organizations, but also institutions and practices for society as a whole. Retaking from the point left in the previous chapter with North's insights about economic change, the following sections will present the concept of learning that will be the keystone of this research. In order to reach the processes in operation in the abstract level of political economy, I will build on the idea of Distributed Cognition beyond individual boundaries borrowed from Psychology and Anthropology, as well as on a literature from Business Management and Organizations Theory influenced by the perspective of System Thinking. As this is a ubiquitous subject, the scope of this inquiry is delimited to references that study the feedback dynamics of learning in complexity.

Mantzavinos, North and Shariq (2004) define learning as the “complex modification of mental models according to the feedback received from the environment”<sup>38</sup>. Environmental feedbacks can reinforce mental models, consolidating beliefs, or lead to their creative modification. The authors explain that in the societal level learning occurs collectively, modifying shared mental models and producing belief systems that will support institutions, policies and, ultimately, economic performance. Since the mind interprets reality in  $t_2$  on the basis of shared mental models of  $t_1$ , path dependence in economic growth can be traced from the cognitive level. While this “cognitive approach” allows learning processes to connect very distinct levels of the political economy of development, from individual cognition to economic prosperity, it seems the evolutionary explanation of the emergence of institutions presented in the article is still more a functionalist process of selection than an adaptive process of learning.

The authors explain the rise of the state as a solution for the problems of trust and protection from aggression. When a society grows bigger and relationships become increasingly impersonal, “individuals capable of learning are bound to realize” that the probability of dealing with defectors increases. This collective lesson implies a demand for protection that will be provided by many protective agencies, because of the higher transaction costs of the formation of coalitions for each time defection occurs. With access to violence mechanisms with nothing else than informal rules to constrain them, the protective agencies engage in a trial and error process of competition and cooperation, “from armed battles to complete

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<sup>38</sup> Mantzavinos, North & Shariq (2004), p. 76.

fusions”, in order to keep control. They conclude that this evolutionary process generates a state or states taxing constituents for protection.

The evolutionary process in the selection of agencies is clear, but when learning takes place adaptive efficiency is taken as given: individuals realize the increase of defections and higher transaction costs of certain solutions to make choices. The authors cautiously address the point that from an evolutionary perspective this story is just one of many possible outcomes, but while history takes the path of the emergence of the state because of settled relative costs, learning is still implicit in a model of incentives and constraints.

Transaction costs are, in short, the costs of ambiguity. Imperfect information, unclear rights and inefficient enforcement produce ambiguities that will be objects of bargaining all the way to the courts. Such ambiguities can be reduced by contracts in the free market or by social rearrangements that absorb these transactions in administrative decisions and norms, such as firms (Coase, 1937) or governmental regulations (Coase, 1960). The static way to explain the emergence of the state is that cost and benefit analysis weighed by transaction costs led choices to “agencies” and then to governments. The dynamic explanation might be that ambiguities continuously blocked reflections about adaptive rearrangements in the market, driving history to a reinforcement cycle of power concentration. Perhaps more than the level of uncertainty for political and economic choices, transaction costs influence the kind of learning that prevails. This is an empirical question that I will carry henceforth.

North (2005) takes a step outside the individual boundaries of mental models with Hutchins & Hazlehurst's (2003) concept of "artifactual structure". He points out that what is learned by one generation is transmitted to the other by artifactual structures of beliefs, knowledge, institutions, tools, technology and so on. Such structures shape the "immediate choices of players" as well as provide clues to the dynamics of "success or failure of societies through time". He explains that the richer the artifactual structure, the greater is the reduction of uncertainty in making choices and wider is the range of possibilities of experimentation and creative competition. "The richer the artifactual structure, the more likely are we to confront novel problems successfully. That is what is meant by adaptive efficiency"<sup>39</sup>.

North, Wallis and Weingast (2009) advance in the study of adaptive efficiency as an essential force of long-run stability of developed societies fostered by competition and credible commitments. They explain that open access to organizations and the free flow of ideas enhance the ability of individuals to pursue their interests and find better solutions for new problems, in a Schumpeterian process of political and economic creative destruction. Conflicts related to this competition of ideas do not generate disorder because commitments established by institutions are credible and impersonal in the so-called "open access" social order. On the other hand, in "natural states" privileged groups control valuable resources and activities constraining the ability of individuals to

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<sup>39</sup> North (2005), p. 70.

explore new opportunities and solutions. Competition is limited and institutions are unable to create credible commitments in the economy and the polity.

Like in North (2005) and in Mantzavinos, North and Shariq (2004), in North, Wallis and Weingast (2009) adaptive efficiency is characterized as a process of competition that selects solutions framed by a set of institutions that produce better choices. These insightful works advance in the concept of development as an evolutionary process and provide ideas for a grounded concept of learning in this context. One can picture a process in which mental models modify, artifactual structures evolve, new solutions are continuously tested and mental models change again. However, in order to figure out how to improve adaptive efficiency to produce prosperity one should observe not only the selection of solutions, but also how they are produced. Rather than between solutions, the competition is between the learning processes that produce such solutions to never ending new arising challenges. It seems the study of development in terms of adaptive efficiency is beyond mental models, frames for choices and arenas of experimentation of ideas and solutions. Hutchins takes this step further by understanding artifactual structures and mental models as media of the learning process in distributed cognition.

Hutchins (1995) is an important reference to this research because his approach of distributed cognition brings together learning and complexity in a concrete and observable manner. Likewise my concern about stocks and flows in Political Economy, one of Hutchins's motivations is the rejection of the idea of culture as a



“collection of things”<sup>40</sup>. In the manner of Hayek, he proposes that culture is an adaptive process that accumulates partial solutions while our everyday practices are enacted. He explains that as a consequence of each task performance and its repetition over time individuals reorganize their minds to develop skills, while partial solutions are crystallized in material artifacts and in the social organization of the work. He understands stocks of knowledge as well as logbooks and pencil marks on charts as residua of this process, observing the microgenesis of cultural elements in the details of the ongoing practice.

In his research, Hutchins describes navigation tasks performed by a team at the bridge of a Navy ship as a process of propagation and transformation of representations distributed across members of the group, through time and beyond the “skin or skull” of an individual. He believes the real power of human cognition is the ability of bringing bits of structure into coordination in order to organize solutions, defining learning as a process of “adaptive reorganization in a complex system”<sup>41</sup>. He explains that in the task of “fixing” the position of the ship a “wave of organization” propagates through time and space from external media, such as written procedures and navigation instruments, to internal media, such as individual minds that coordinate words and meanings, and back to external media, such as the map where the position is marked. Cognition is distributed in the sense that cognitive processes related to memory, reasoning and learning are not closed within the boundary of individual minds, but can also be observed in the social and material world, coordinating minds and material

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<sup>40</sup> Hutchins (1995), p. 354.

<sup>41</sup> Hutchins (1995), p. 289.

artifacts. Learning is a cognitive process of adaptive reorganization of parts of a system in relation to other parts.

Hutchins states that the conduct of the activity, the development of the practitioners and the evolution of the practice are all the same process, explaining that its products go beyond the end of the task as new ways of solving problems written down in improved procedures or remembered as memories, habits and skills. A learned lesson shapes the immediate performance and the future career of a military officer, rewrites the formal process of a task in manuals that will be used by different crews, and may change patterns of behavior and social organization that affect the whole corporation. In this sense, Hutchins' concept of learning has the plasticity of a wave of adaptive organization that propagates in all dimensions connecting subsystems, that can be seen as individuals, teams or sub-processes, in various levels and time scales.

It seems the study of distributed cognition throughout the web of connected subsystems is in the domain of Hayek's epistemology of complexity and provides evidences of his hypothesis of decentralized adaptive learning. When the ship's propulsion system failed during an entry into San Diego Harbor, Hutchins observed two modes of adaptive responses to the problem of fixing their position without the support of crucial electrical devices. The first was an unreflective process of adaptive interactions among subsystems in which the calculation of the position of the ship was made differently depending just on the availability of data, without further reflection upon neither the local nor the overall process. The

second was the case of local design, in which one person was aware that was falling behind and implemented a local change in the calculation process that in sequence triggered both unreflective and locally designed adaptive responses in other subsystems. Hence, the ship is a complex system of processes and mediating artifacts in which organization is achieved by adaptations to emerging circumstances. Learning is this process of adaptive reorganization in which representations of reality change in mental models and material artifacts. Hutchins points out that systems change in part by an evolutionary process and in part by design. Even when subsystems change by local design, adaptation in the system level is evolutionary in the sense that many other subsystems may present unreflective responses to such change. With an anthropological approach, he doesn't make judgments about which learning type is desirable, but rather realizes that solutions "we recognize in retrospect as being just the sort of solution we would hope designers could produce" are a "product of adaptation rather than of design"<sup>42</sup>.

I think Hutchins' concept is powerful for many reasons. First, the learning process that builds artifactual structures is explicit from the very beginning as a wave of organization connecting the microgenesis of capabilities and institutions. In this sense, it has the flexibility to navigate in various levels and time scales, from individual skills to cultural elements. Second, the identification of reflective and unreflective learning types and their combination in evolutionary processes may help us explain unintended and even counterintuitive patterns in social systems,

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<sup>42</sup> Hutchins (1995), p. 317.

including in the political economy of development. Third, the proposition that cognition is distributed has interesting empirical implications. It encourages not only ethnographic approaches, as adopted by Hutchins with recording and observations *in loco*, but may also inspire the researcher to see collected data as residua of learning waves through time. In order to identify what types of learning are at play, one can analyze data not just from “internal media” by interviews, surveys or experiments, but also from “external media” such as databases, reports and archives.

Hutchins’ perspective is by no means limited to his ship’s problems. One can imagine learning as the rearrangement of processes within firms deciding to contract or expand activities in order to reduce transaction costs, or as the improvement of institutions to coordinate relations between labor and business in varieties of capitalism, or yet as the reengineering of “routines” in innovation processes of evolving technologies. I imagine learning as the adaptive reorganization of capabilities and institutions in the pursuit of prosperity. These processes of change can be unreflective, reflectively designed or evolutionary combinations of both. While in the level of the system the challenges are always changing and never completely known, Hutchins offers an approach that traces learning from the level of local design in subsystems. In order to hypothesize about the relations between such learning types and local contributions to development I need to explore in depth the types of learning observed in organizations and, equally important, the factors that produce the distinction between these types, weakening or strengthening learning feedback links in the

process of development.

### **3.3. Learning Organizations**

Studies about learning in complexity that address those questions are very traditional in Business Management and Organizations theories. While some of the most influential scholars pointed out the subject of change as the central theoretical issue of the field<sup>43</sup>, organizational learning became the fundamental process of competitive advantage in continuous change for a part of the literature influenced by the approach of System Thinking. With roots in the general system theory<sup>44</sup>, this literature was initially studied as the dynamics of complex systems by Forrester (1961) and developed in the subfield of organizational learning by scholars such as Senge (1990) and Sterman (1994).

Forrester (1961) was a major breakthrough for decision-making in the field of Business Management. Applying the idea of feedback control from his engineering background, he demonstrates how the amount of corrective action based on misinterpretations of time delays in interconnected systems often lead to costly fluctuations in processes of production and distribution. He explains the poor performance of inventory management in factories, distributors and retailers as the result of the inability of managers to grasp the properties of the

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<sup>43</sup> Drucker (1985); Fahey (1999); De Geus (1988).

<sup>44</sup> Inspired by his experience as a biologist, Bertalanffy (1968) states that the scheme of isolable units acting in one-way causality has proved to be insufficient and, in all fields of science, we should think in terms of systems of elements in mutual interaction. However, he explains, while Natural Science reveals laws about the relations between its elements, such as particles, atoms, molecules and living systems in various levels, Social Sciences have the challenge to deal with human beings and their self created cultural universe.

interrelations of the system instead of the characteristics of the individual units. Forrester argues that the company should be recognized not as a collection of separate functions but as a system in which the flows of information, materials, capital and so on lead to growth, fluctuation or decline. His research anticipated the emphasis on feedback cycles and time delays that would be the fundamental principles of business management a few years later<sup>45</sup>.

Forrester pioneered business processes modeling as complex systems in order to deal with the limitations of human cognition in the face of complex social organizations. Political scientists and economists usually discuss such limitations as “bounded rationality”. Simon (1972) explains that because rationality is bounded by uncertainty, limited information and complexity, decision-making is more a problem of “satisficing” than optimization. This assumption permeates the referred literature on institutions and evolutionary economics, with emphasis on uncertainty and limited information though. While institutions turn the uncertainty of transaction costs<sup>46</sup> into risks that entrepreneurs can measure to make decisions, evolutionary economists embrace uncertainty and limited information in the process of innovation<sup>47</sup>. This literature also highlights the complex character of the political and economic milieus, but mostly understood as a complicated web of variables and strategies. Simon (1972) points out that the chess players’

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<sup>45</sup> For instance, the principle of feedback is behind widespread managerial tools such as the PDCA cycle (plan-do-check-act) of Total Quality Management and as the Balanced Scorecard of strategic management; the reduction of time delays are the focus of Japanese models of process management such as Just in Time.

<sup>46</sup> The seminal discussion proposed by Coase (1937) is mostly about how the level of uncertainty in the use of the price system, access to information and costs of negotiation explain which transactions the firm will absorb into the organization and which it will keep in the open market.

<sup>47</sup> “Our greatest intellectual debts are to Joseph Schumpeter and Herbert Simon” (Nelson & Winter 1982, preface, ix).

difficulty to behave rationally is a matter of complexity rather than uncertainty, because of their “computational inability” to ascertain all the strategies of the game. Pierson (2000) and North (1990) deal with the “institutional density and opacity” of politics and the “massive increasing returns” produced by the “interdependent web of an institutional matrix”, respectively. Nelson & Winter (1982) go further, insofar they deal with the intrinsically dynamic character of the evolutionary perspective and develop their model with simulation techniques. Starting with Forrester, System Thinking scholars contribute with a closer look to the structural elements of dynamic complexity and the barriers they impose to learning.

Sterman (1994) explains that dynamic complexity arises even when there is no combinatorial complexity, i.e. systems are simple in terms of the number of interrelations between variables. While people generally adopt an event-based, linear open-loop view of causality, complexity presents itself in real life with feedback connections between cause and effect, tightly coupled variables, as well as time delays between action and response and in the reporting of information. These structural elements produce path dependence, counterintuitive responses and nonlinearities that are difficult to grasp or predict. He presents several field and laboratory experiments in which subjects fail to appreciate such complexities, including cases with professionally trained personnel and treatments in which the structure of causal interrelations is revealed<sup>48</sup>. Senge (1990) points out that as a

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<sup>48</sup> Sterman (1994), p. 303. For example, the “Beer Game” is a lab experiment in which subjects simulate management in a supply chain of production and distribution. Even experienced managers

consequence of such limitations certain systemic structures occur again and again even after being well known to us. This is the case of military conflict escalation, the tragedy of the commons, price wars, real state boom and boost, etc. These “archetypes” are vicious cycles locked in path dependent patterns that are difficult to be dealt with by the human mind. Regarding the problem of development, the empirical question is whether dynamic complexities are impediments to learning that lock in less developed societies. Are there misperceptions of feedback dynamics, time delays and nonlinearities affecting the implementation of public policies and private projects? Are such complex dynamics spontaneous or designed? The empirical question of my research has now dynamic complexity and transaction costs as two elements affecting learning types that I intend to investigate.

In order to overcome the impediments to learning of dynamic complexity, scholars of system thinking suggest a systemic perspective to grasp the feedback structure and the dynamics of social systems. Sterman describes learning as “a feedback process in which our decisions alter the real world, we receive information feedback about the world and revise the decisions we make and the mental models that motivate those decisions”<sup>49</sup>. There are two learning cycles in this definition; in the first cycle decision makers compare the information acquired from reality to a goal and take action to move the trajectory toward the desired state; the second is a reflective cycle in which the assumptions that

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are tricked by misperceptions of time delays and nonlinearities, incurring in costly results. The average cost found by Sterman was ten times greater than optimal.

<sup>49</sup> Sterman (1994), p. 291.



motivated the previous action are called into question. Senge (1990) explains that the first is the cycle of imitation and repetition, in which individuals and groups adjust their behavior according to fixed goals, norms and assumptions. The second is the “generative” cycle, in which individuals and groups take action creatively and goals, norms and assumptions are open to change. While the first learning type is a corrective cycle similar to the unreflective adaptations of the crew of Hutchins’ ship to the availability of data, the second can be compared to the reflective local design that changed the way data was used. In the second cycle there is reflection on the complex structure of reality and intentionality to alter its representations in mental models as well as to design new solutions and rules. Sterman states that for learning to occur the two loops must work and we must cycle around them faster than the relative rate of change in the real world.

Both Sterman and Senge refer to the typology of Argyris and Schön (1978) of single-loop and double-loop learning, applying the approach to complex systems. Defining learning as the “detection and correction of errors”, Argyris and Schön study how individuals and organizations simply change strategies or run the double-loop reflection on the strategy’s “governing variables” when something goes wrong. They present empirical evidences that individuals are acculturated to be single-loop learners, encouraged to learn “as long as the learning does not question the fundamental design, goals and activities of their organizations”<sup>50</sup>. This discussion adds to our inquiry the idea that it is important to observe how systems deal with errors in order to understand learning types and, moreover, how

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<sup>50</sup> Argyris (1976), p. 367.

unreflective types of learning can be intentionally reinforced.

Argyris (1976) points out a set of factors that inhibit learning within groups and organizations such as interdepartmental and interpersonal conflicts, political and organizational exchanges, competitive games and bargaining, parochial and personal interests, ideologies, cognitive rigidities, concepts of loyalty and miscommunication. He argues that effective learning is ultimately weakened by the underlying behavioral strategy of control over others, explaining that the primary strategy of unilateral control produces defensive and closed groups, affecting the production of valid information and freedom of choice. Defensiveness results in less public testing of ideas, little genuine feedbacks, reduced opposition and a frustrated leadership that will viciously increase control and demand loyalty. He states that all these factors tend to become more operative as decisions become important and threatening, reinforcing the single-loop pattern in all kinds of organizations.

Argyris is clearly discussing the politics of organizations as a fundamental factor that inhibits or enhances learning. He points out that “giving the meaning of a concept to others and defining its validity for them is one of the most powerful ways of control”<sup>51</sup>. This statement links the idea of learning types to the literature on institutional change discussed in Chapter 2. For Mahoney and Thelen (2010) institutional change results from the relation between power and the meanings of institutions. Depending on the level of discretion allowed, agents change or

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<sup>51</sup> Argyris (1976), p. 368.

comply with institutions. In this sense, certain power relations may determine meanings that reinforce unreflective learning processes in which compliance is a key characteristic. I think this is a relevant mechanism through which power produces path dependence and should be added to the list of possible sources discussed by Pierson (2004)<sup>52</sup>. One can also understand the ideal types of political economies discussed by Hall and Soskice (2001) and Schneider (2013) as learning systems, formulating the hypothesis that the hierarchical power relations in Latin America produce more ambiguity and defensiveness than coordinated or liberal markets, resulting in poor learning processes and path dependent patterns of underdevelopment. Expanding Argyris' findings beyond organizational boundaries, I would complement my empirical question about transaction costs and dynamic complexities with the issue of control over meanings. How do transaction costs, dynamic complexities and power relations influence the kind of learning that takes place in different societies? More specifically, which ambiguities, misperceptions and defensive reactions are designed and which emerge spontaneously and how they undermine reflective learning?

### **3.4. The Production of Social Goods as a Learning System**

Before moving to the empirical chapters, a few examples might clarify the concept of a learning system in the context of development, as well as the

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<sup>52</sup> High start-up costs, coordination effects and adaptive expectations of the collective nature of politics; increasing returns of institutional density; asymmetries determined by political authority; and biased mental models.

theoretical arguments discussed so far. Consider the production of social goods<sup>53</sup> by the government in a process in which subnational entities such as states make investments with credit contracts from a development bank. In order to access each planned disbursement the states need to accomplish some requirements, such as those regarding environmental licensing and the correct expenditures report of the previous tranche. Of course, some states will be more successful than others, providing solutions for the requirements, managing their projects and delivering their contribution to local development. For those that fail to access the resources, the usual responses of the creditors are financial covenants in contracts, either with incentives or sanctions, as well as training public servants in order to increase efficiency in the requirements' task. This is an example in the micro level of the solutions prescribed by development theories that take institutions and capabilities as explanatory variables. On the other hand, a learning approach would ask, first, how are the states dealing with their mistakes? Are they keeping the same pending requirements or anticipating future solutions?

Consider now one state that, locked in the unreflective learning type, couldn't build a school on time because of recurrent pending environmental requirements, and another state that after experiencing the same problem for a while created an on line application and a law to fast track projects with low environmental impact. Moreover, the successful state became a benchmark when best practices in environmental regulation evolved. If both started with the same incentives in

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<sup>53</sup> In the sense that they are not strictly public goods, but rather any project considered meritorious to be part of a public program of investment, such as water & sanitation, hospitals, schools, roads, etc.

terms of the expected payoffs, contracts and regulation, the question is why did one reflectively solve the problem changing capabilities and institutions, while the other didn't? One quick answer would be in the power of bargain based on the importance of the project. Larger investments would have more influence over bureaucracies, informally getting advantages to go over bureaucratic requirements. We will see in the empirical chapters that this is not the case. Another answer would be in different levels of development, with the unsuccessful state falling behind in education, economic performance, institutional effectiveness and so on. While this answer would describe the status of the problem it wouldn't explain the inability of the state to change. It would describe the stocks of the artifactual structure without the flows that change them. What would be the dynamic explanation in terms of adaptive efficiency? Which impediments to adaptively reorganize in order to carry on their projects did the unsuccessful state face? The explanation developed in this chapter is that hierarchical learning systems might create defensiveness, ambiguity and misperceptions of dynamic complexity. The following is a real example in which I observed these barriers to learning.

With the best of the intentions, one state decided to have the signature of the Accountability Office before sending each of the expenditures reports to the development bank, a process of compliance that usually takes place afterwards. The timing of compliance and project management were quite different and frequently engineers had the feedback from the office too late to make adjustments, making the new process strictly bureaucratic. The new procedure

also created ambiguities and, apprehensive with the kind of control they would be exposed to, engineers and bureaucrats became more and more defensive, providing the minimum information and avoiding any kind of creative solution for the project. Because of misperceptions of timing and defensiveness, the reporting process of each tranche was extended for weeks with marginal quality improvement and all projects were rescheduled several times. Instead of developing for a prosper mix of project management capabilities, creative institutional change and entrepreneurial practices, the state reinforced this vicious cycle for a long time. A good intention enacted in one subsystem generated adaptive reorganizations in other parts of the system that locked the system in a path of low performance.

Summing up, this chapter contains three fundamental issues of this research. The first is the concept of learning as a process of adaptive reorganization in society as a system. This definition makes explicit the microgenesis of capabilities and institutions as products of learning processes. Second, such systems and their subsystems deal with errors differently, learning reflectively, unreflectively or maybe not learning at all. Learning is unreflective when adaptive reorganization occurs without reflection about the underlying structure of the problem. On the other hand, learning is reflective when adaptive reorganization designs solutions that challenge the structure of the problem. These learning types combine in evolutionary processes that may produce unintended and counterintuitive consequences such as unfavorable path dependent patterns in less developed societies. Third, Organizations Theory adds to the institutional approach some

insights for investigating these dynamics through the impediments to learning. The literature discussed here is not exhaustive, but provides the interesting starting point of the empirical question about how learning types are affected by dynamic complexity, transaction costs and power relations.

#### **4. The Hypothesis of Adaptive Development**

Chapter 2 pointed out the unexplored role of adaptive learning in the subfield of Political Economy of Development. It called attention to the importance of pursuing a theory of change beyond incentives and constraints that frame choices. I argued that the idea of learning as a source of reinforcement should be considered in the study of path dependent patterns such as seen in developing and underdeveloped societies.

While Chapter 2 was an attempt to show the unexplored avenue in which this research is located, Chapter 3 was about the interdisciplinary concept of learning on which I build my hypotheses. First, intending to make explicit the learning processes hidden in the feedback dynamics discussed in *New Institutional Economics and Varieties of Capitalism*, I suggested an evolutionary approach that takes development by its composite systemic processes rather than by explanatory variables in unidirectional causality. Understanding development as a process of fortune taming by decentralized adaptive learning, I argued that society should be taken as a learning system in which capabilities and institutions co-evolve. In this context, I looked at Distributed Cognition as a perspective to complex systems that would allow a drill down to the microgenesis of development in the learning processes that take place in problem solving tasks by adaptive reorganization. The proposition that cognition is distributed has the interesting empirical implication of turning collected data into residua of learning waves through time. With insights from this perspective as well as from Organizations Theory I argued that



capabilities and institutions are products of reflective and unreflective learning types that combine in evolutionary processes. Finally, I discussed how dynamic complexity, transaction costs and power relations might produce ambiguities, defensiveness and misperceptions of feedbacks and timing that influence learning processes in path dependent cycles of development. This discussion inspired the empirical question of whether these elements are designed or emerge spontaneously, as well as how they undermine reflective learning in unfavorable developing processes.

This multidisciplinary approach centered on learning processes beyond the human mind and intentionality may help us understand the dynamics of development in terms of how capabilities and institutions evolve. Moreover, this approach may have practical implications for public policies in which the mainstream solutions of incentives and capabilities have been failing, insofar it allows the identification of patterns that block learning and sheds some light over the path of prosperity.

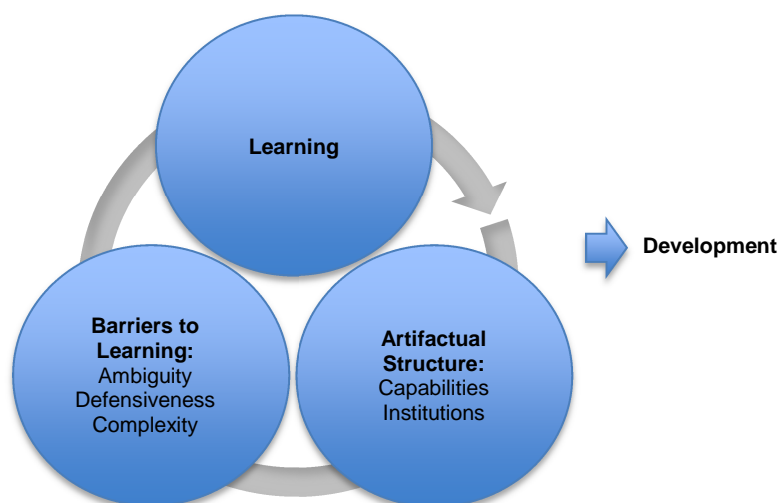
#### **4.1. Analytical Model**

Chapter 3 presented the concept of development as a process of adaptive learning. Development is adaptive because groups reorganize the next trails taking into account the previous errors, adjusting strategies unreflectively or by reflective design. Furthermore, as pointed out by Hayek and Hutchins, social systems reorganize adaptively in the global level even as a response to local design. Adaptive development is a process because this research looks at the dynamics of

the flow rather than static stocks. Rather than stocks of knowledge, human capital or any other element of the artifactual structure, the object of interest is the dynamics of learning processes that produce such stocks. The next chapters will analyze the fitness of types of learning in certain environments and how they produce or slow down prosper societies. Learning fitness will be studied as a measurement of path dependence in the process of development.

I already stressed that this research follows an epistemology of complex phenomena, rather than a positivist approach of unidirectional causality. Development and learning are not only mutually constitutive but the pattern of development emerges from the relations between the elements of the system rather than from individual variables. Think of the relation between the sets of variables presented in Figure 4.1 as a continuous causal chain. In a virtuous cycle, learning produces better capabilities and institutions that reduce the barriers to learning. In a vicious cycle, lower learning produces inferior capabilities and institutions that let barriers grow and undermine learning again. When this causal chain works in virtuous cycles, development is unlocked. When it works in vicious cycles, society is locked in a path dependent pattern of stagnation.

Figure 4.1 – Adaptive Development as Virtuous or Vicious Cycles



Hutchins (1995) summarizes his argument about cognition in the wild with a “moment of human practice”<sup>54</sup> in which the activity, the development of the practitioner and the development of the practice occur simultaneously. I build my research on an analytical model inspired by this idea but adapted to the episteme of the political economy of development. Human action is still the engine of the model but the residua of the learning wave of reorganization I will observe are capabilities and institutions. Capabilities include knowledge, skills and attitudes of individuals and groups. Institutions are formal contracts, laws and other written rules such as business processes described in organizational norms; and informal norms, codes of conduct and cultural elements manifested in human action and represented in material artifacts.

This first set, corresponding to North’s “artifactual structure”, represents the

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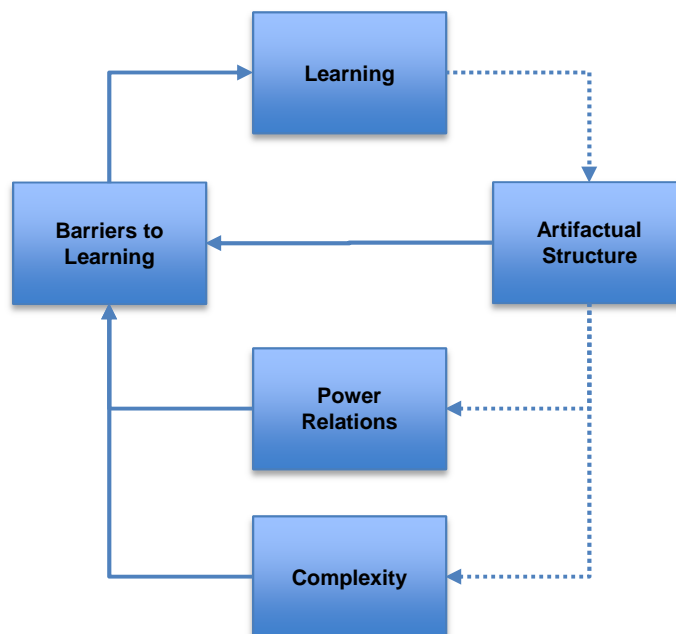
<sup>54</sup> Hutchins (1995), p. 372.

variables that are traditionally the primary causes of development in the Social Sciences. As pointed out in the previous chapters, New Institutional Economics, Varieties of Capitalism and Evolutionary Economics implicitly relate these variables to learning in the process of development and economic growth. North (2005) summarizes this link as the relation between artifactual structures and adaptive efficiency, emphasizing the ambiguities of transaction costs. My attempt to make a theoretical contribution here is making explicit the dynamics of learning processes that affect and are affected by such variables. Empirically, I will measure path dependence and trace how ambiguities and other barriers to learning produce such locked patterns. I will try to observe “in the wild” the microgenesis of capabilities and institutions when reflective, unreflective and no learning are at play, with main focus on how the reorganization of this artifactual structure affects learning fitness. Learning fitness, as a measurement of adaptive development, is the dependent variable.

It was also pointed out previously that capabilities and institutions influence learning not only by directly reducing ambiguities of transaction costs, but also by the way they distribute power and unveil dynamic complexity. Figure 4.2 detaches these variables from the artifactual structure and represents the feedback cycle that enhances or undermines the barriers to learning. Albeit they receive feedbacks from the system in the long run, as represented by the dashed lines in the figure, I will assume these variables can be taken as exogenous in the short term. In fact, in real life one will always observe better and worse artifactual structures, power relations and levels of complexity operating as part of endogenous or exogenous

processes. Consider the example of an agent trying to access credit for an infrastructure project. In the long run, experience may change technical knowledge, regulations and ethics in the sector, as well as influence agent's organizational structure and managerial complexity in project design. Yet, policy makers can exogenously change credit rules, agent's type selection and project characteristics if they believe these choices enhance learning, attempting to shift vicious into virtuous cycles. In this sense, each of these categories can be taken as an independent variable in the model or, particularly in this research, as explanatory factors of learning in public policy analysis.

Figure 4.2 – Analytical Model



In summary, the artifactual structure is defined as capabilities and institutions; and barriers to learning as ambiguities, misperceptions about dynamic complexity and

defensiveness of unreflective and uncooperative groups. In this model, artifactual structure, power relations and complexity are independent variables; learning is the dependent variable; and barriers to learning are intervening variables.

The next section will explain the three hypotheses of the research design, presenting the operative concepts of the variables of study. The first hypothesis requires an analysis about the dynamics of learning fitness. The second is an inquiry on the relation between this dependent variable and the independent variables, namely power relations, complexity and the artifactual structure of capabilities and institutions. The third will demand a qualitative design of process tracing that includes the barriers to learning: misperceptions of dynamics, ambiguity and defensiveness.

## **4.2. Methodology**

In the operative definition of this research, *learning is adaptive reorganization in the process of trial and error* in society as a system. Subsystems respond to errors differently, learning reflectively, unreflectively or maybe not learning at all. Learning is unreflective when adaptive reorganization occurs by the application of a solution according to established knowledge, goals, norms and assumptions, without reflection about the underlying structure of the problem. On the other hand, learning is reflective when adaptive reorganization is an intentional design of a solution that challenges established knowledge, goals, norms, assumptions or any element of the underlying structure of the problem. I study learning in the

microgenesis of the process of development, in the on going problem solving tasks agents face in the production of social goods, specifically in the access to funding for development projects in the sector of water & sanitation. Agents are states, municipalities and state-owned companies – publicly traded or not – with the same goal of providing the social goods, submitted to the same sectorial regulation and very similar incentives in terms of the funding process. They are the units of analysis in which the learning types competition takes place. Since they are competing, learning types occur simultaneously in all levels, from individual minds to project teams, agents and society, gaining and losing shares through time. Shares are relative frequencies of learning types that prevail in the micro level of the problem-solving task that, in this empirical analysis, is the project compliance. In this sense, the data represents snapshots of winning learning types that are continuously challenged by others.

States, municipalities and companies need to comply with certain requirements regarding environmental licensing, property entitlement, bidding procedures and engineering projects in order to access federal funding for investments in water and sanitation systems. I use a database with information provided monthly by project managers of the Brazilian Development Bank, from October 2010 to March 2016, about infrastructure operations with states, municipalities and companies. For every month in the period the database shows whether each project complies or not with each of the four mentioned requirements. I coded projects' compliance to the bank's requirements, classifying learning types  $i = (0,1,2)$  as follows:

*$i = 2$ , if compliance mistakes in  $t_n$ ,  $t_{n-1}$  and  $t_{n-2}$  are zero;*

*$i = 0$ , if the same compliance mistakes in  $t_n$  were in  $t_{n-1}$  and  $t_{n-2}$  or*

*if there are more compliance mistakes in  $t_n$  than in  $t_{n-1}$ ;*

*$i = 1$ , for the remaining possibilities.*

When agents reorganize themselves in a way that anticipates future problems and avoid compliance mistakes, there is a superior type of learning going on ( $L_2$ ). The other pole is when they keep making the same or more mistakes and much less learning is at play ( $L_0$ ). In the remaining possibilities of changing compliance mistakes, some learning must be happening ( $L_1$ ). For example, if a municipality complies with all requirements except the environmental license for a whole quarter,  $i = 0$ . If the municipality complies with the environmental license, but now can't access the money because of another requirement, e.g. the bidding procedures,  $i = 1$ . Finally, if the municipality has no pendent requirements for three months,  $i = 2$ . I assume initially that some reflection upon the underlying norms and beliefs occur in  $L_2$ , but the in depth analysis and confirmation of such assumption is the object of the case studies, the last step of this research strategy.

Theoretically, the use of compliance as a measure of learning brings together the idea of correction of errors from the literature on Organizational Theory<sup>55</sup>, the idea of progress as an adaptive process of trial and error from Political Economy<sup>56</sup>

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<sup>55</sup> Argyris and Schön (1978).

<sup>56</sup> Hayek (1960).



and the emphasis on the on going practice of Distributed Cognition<sup>57</sup>. Empirically, this operative measurement has the flexibility to allow further comparable research on different kinds of agents and subsystems, including various sizes of firms, sectors, industries, cities and societies.

This research strategy has three steps: a large  $N$  exploratory analysis, an evolutionary approach to study learning fitness and a set of case studies for process tracing. Next section and Chapter 5 are the first and second steps, respectively. I expect to observe higher fitness for unreflective learning as the evidence of path dependence; as well as find higher fitness for reflective learning when power relations are less hierarchical, the complexity of projects is lower and higher levels of development represent the mix of capabilities and institutions. Chapter 6, the third step, is the study of cases that trace the process of adaptive development. I look for data in assessment reports, as well as conduct interviews with experienced professionals to understand the feedback dynamics of the relations between barriers to learning, learning types and the capabilities and institutions that unlock prosperous development. I expect to find evidences that misperceptions of dynamic complexity, ambiguities and defensiveness are barriers that lock subsystems in unfavorable patterns of unreflective learning. This strategy unfolds in three hypotheses as follows.

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<sup>57</sup> Hutchins (1995).

*H1: Learning is a source of path dependence in the process of development.*

In the perspective of adaptive development, learning fitness is a measurement of path dependence. Friedman & Sinervo (2016) present models in which fitness is estimated with data of the shares of different traits with studies in biology. They also explain examples of “frequency dependence” in which fitness and shares are related in increasing or decreasing returns. Coding the compliance mistakes as described, I have a database with the shares ( $L_i$ ) per learning type over time in order to estimate fitness ( $W_i$ ) as well as the possibilities of frequency dependence. Evidences of virtuous path dependent patterns may be provided by the result of higher fitness for reflective learning. On the other hand, the vicious cycle in which less developed subgroups are locked in may be observed in higher fitness for unreflective learning. In Chapter 5 I will apply techniques of Evolutionary Game Theory, as introduced by Friedman & Sinervo (2016), in order to find evidences to support the hypotheses 1 and 2.

*H2: Hierarchical power relations and complexity reduce the fitness of reflective learning.*

The subsequent question is whether the relative fitness of reflective learning is different in distinct power relations and complexity levels. The “ecology” at stake is about agents managing infrastructure projects of various sizes in regions with different levels of development. Agent is taken as a category of power relations, considering two types: market based relations, represented by publicly traded

companies; and hierarchical relations, characterized by municipalities, states or state owned companies. The size of the investment is the measurement of complexity, the second explanatory variable. The larger the project, the higher will be the number of people, the amount of resources and the intensity of the flow of information, consequently increasing the odds of more misperceptions of feedback dynamics and time delays. I also control for the artifactual structure of capabilities and institutions, taking the municipal human development index (HDI) as a proxy. Section 4.3 will explain in detail this coding and explore the data in order to find statistical support for the choices of variables. In this section, complexity and HDI will be taken as continuous variables in a logit model. In the next chapter I will estimate the fitness and study the dynamics of learning types with a comparative analysis within the categories of the explanatory variables. In this case, agent types, complexity of projects and HDI will be categorical variables with two levels each.

*H3: Vicious cycles of unreflective learning are reinforced by ambiguity, defensiveness and misperceptions of dynamic complexity.*

If one group of projects represents an environment in which reflective learning takes too long to blossom, something other than the financial incentives, contractual constraints and capabilities provided by the Bank to the agents must be affecting the payoff (fitness). Chapter 3 proposed the hypothesis that misperceptions of dynamic complexity, ambiguity and defensiveness are barriers to learning. In order to analyze whether these elements are sources of vicious

cycles of unreflective learning, in Chapter 6 I will study selected cases in a process tracing analysis.

Project teams in each case receive performance reports from the agents and produce assessments. I analyze assessment reports of 8 cases, selected by the combination of agent types, complexity and levels of development. The analysis of these reports, which the Brazilian Development Bank keeps in digital archives, intends to identify and classify the challenges project managers encountered to comply with the requirements. I map the learning processes with special attention to the assumption of reflective learning, trying to figure out whether a case builds the ability to anticipate requirements because of reflectively designed change. A state that improves performance creating an environmental law or changing the licensing process is a case of reflective learning, for instance. I also conduct interviews with experienced project analysts to reach political and organizational aspects that are not part of the formal reports. Analyzing these processes and keeping the proposed analytical model in mind, two patterns are traced: a virtuous and a vicious cycle. I expect to find cases of virtuous cycle and cases of vicious cycles, according to how capabilities and institutions change, and how this set of variables affect the barriers to learning.

### **4.3. Exploring the Data**

This section explores the data of the quantitative approach, clarifying the measurements of each variable while presenting statistical support for the choices

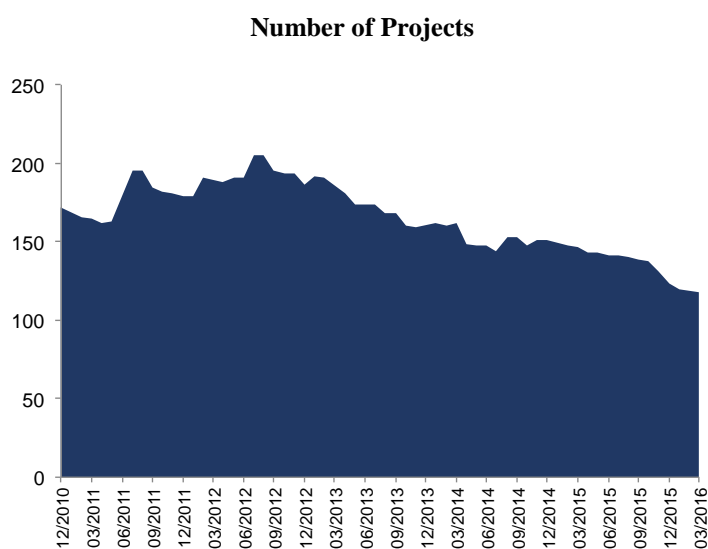
of agent type, project complexity and municipal human development index (HDI) as categories of study. The exploration starts with information about number of projects, learning shares and sectors, continues disclosing the levels of each category and concludes with a logistic model to estimate the odds of certain agent type, project complexity and HDI level to perform reflective learning.

In the explained methodology, the calculation of learning types requires up to three months, making the two initial months of the data only the starting base of a total of 58 months. The sample is a portfolio of credit operations that starts with 172 projects and ends with 118, oscillating a little because of new projects but mostly as the result of the natural life cycle of projects that finish or are cancelled. I drop them just after these events occur to avoid inflating the results with learning measurements that would be just repetitions of the last active month. Approximately 14% of the projects are active for the whole period and 56% for at least 29 months, or half of the time. This variation makes sense since a project the Bank typically supports would have a construction schedule of two years.

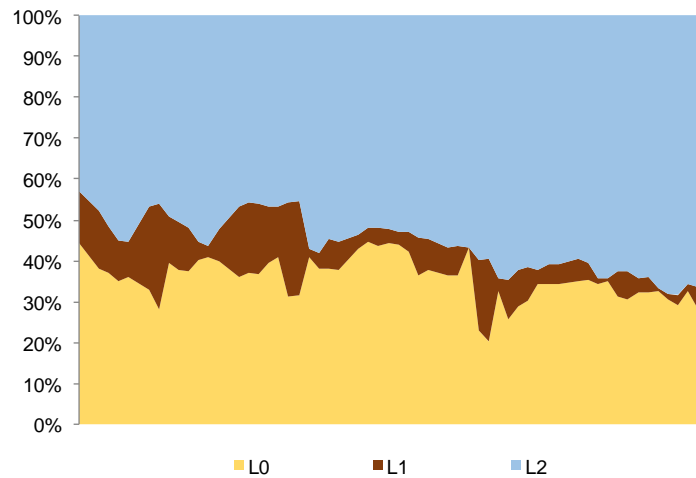
Notice that the idea of a fixed sample of infrastructure projects for the whole timeframe wouldn't be accurate. Besides the life cycle issue, the date a project enters in the process of credit analysis is not the day it was born. Policy makers, project managers, politicians and the public opinion start discussing such projects long before the funding analysis. Moreover, the projects are just the means through which the learning types, our variables of interest, spread out as memes in every direction. Individuals and teams share experiences within and between

agents in formal and informal forums, training programs, seminars and also participating in initiatives planned by the Bank. The projects are the units in which learning types develop and through which they diffuse by the adaptive reorganization of groups formed by engineers, accountants, lawyers, bureaucrats and so on. These teams solve problems in various levels, not only in construction sites, but also in public works, budget, environmental, financial and legal departments of states, municipalities and companies. In this sense, the number of projects is less important than the relative frequency of learning types. Figure 4.3 presents the monthly distribution of projects and the shares of learning types for the whole data set.

*Figure 4.3 – Projects and Learning Types*



### Learning Types



$L_2$  increases its share from 45% to 66% in the portfolio, while  $L_0$  shrinks from 44% to 30%. Is this picture as good as it seems? Will reflective learning  $L_2$  keep increasing its share in the long run, producing solutions for the supply of social goods? If learning types are strategies competing for shares, fitness ( $W_i$ ) is the ability of a learning type ( $L_i$ ) to increase its share. This is the central concept of the empirical analysis and will be the subject of the next chapter. The stacked 100% area chart will be a recurrent tool in this study. The horizontal axis will always be the months between 12/2010 and 03/2016<sup>58</sup>, so it will not be displayed from now on. In the charts about learning types,  $L_2$  will be always on top and  $L_0$  in the bottom.

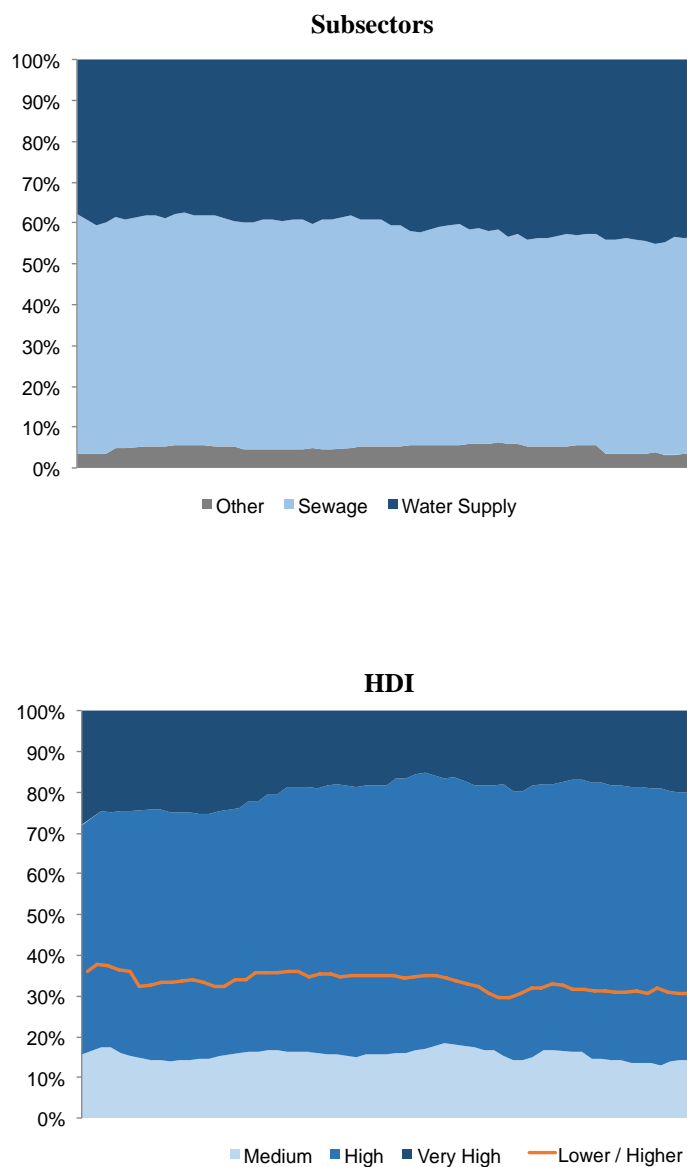
The projects at stake are construction activities of subsectors that can be aggregated in a general sector of water & sanitation. They are facilities of water

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<sup>58</sup> The observations sums up to 58 because of five missing months. I simplify, considering all of them as if they were subsequent in the period because the missing months are far away from each other, in different years.

supply, sewage or combinations of them. The typical project is a small to medium size system of water supply or sewage collection and treatment. Figure 4.4 displays the proportions of projects by subsectors and HDI.

**Figure 4.4 – Subsectors and Human Development Index**





The distribution of observations among sectors as well as levels of development is quite regular through time, even though the projects are not the same for the whole period. The United Nations classifies most of the municipalities in which the projects occur as High HDI, between 0.700 and 0.800. In average, 20% of the municipalities in the sample are defined as Very High and 16% as Medium HDI<sup>59</sup>. The following logit model estimates the marginal effect of HDI, as a continuous independent variable, over the possibility of reflective learning. On the other hand, for the evolutionary model in the next chapter HDI will be a category with two levels. As using the United Nations' ranges results in very small samples for the combination of factors, e.g. Medium HDI with Hierarchy agent type, I use the median of all the indexes that occur in the sample, regardless of for how long, coding Higher for projects in municipalities in which HDI is equal or higher than 0.736 and Lower otherwise. The orange line in the HDI chart shows the proportion of projects above (Higher) and below (Lower) this threshold.

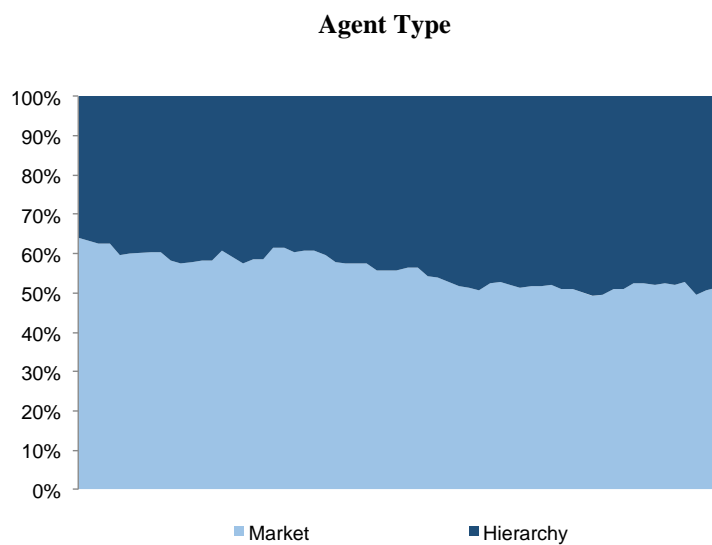
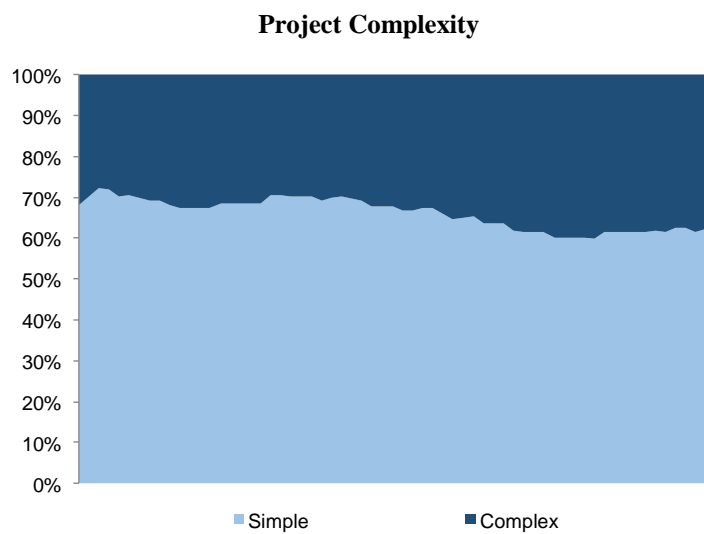
Complexity is also continuous for the logit model and categorical for the evolutionary model, with two levels. "Simple" is lower than R\$ 30 million, an approximated value of a budget of the typical project, which I defined after a careful look at the objects of the contracts represented by the available data: a treatment facility with a network of water supply or sewage collection that covers part of a municipal system. This choice is based on the idea that the relation between investment size and complexity may be non-linear. Imagine the flow of information between team members, for example. The number of connections

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<sup>59</sup> In a few cases that involve more than one municipality the measurement is the average of the indexes.

between members grows faster than the number of members. Hence, it seems plausible to consider that small projects will look alike and complexity will increase fast with the addition of construction sites and teams of workers. Figure 4.5 shows that complex projects are in average 34% of the total.

*Figure 4.5 – Project Complexity and Agent Type*



The organizational structure of the agents is an important and contentious aspect in the discussion about the provision of social goods<sup>60</sup>. New Institutional Economics and Varieties of Capitalism add interesting insights to this debate, which otherwise could be only ideologically weighing market and government failures. As discussed in the previous chapters, NIE introduced the adaptive feature of the market into the organizations as strategic choices between aggregating and disaggregating activities, depending on the costs of transaction. Williamson (1991) summarizes this idea contrasting Hayek's spontaneous order of market relations to the purposeful cooperation of formally organized hierarchies. He argues that hierarchies replace market incentives, which are typically driven by relative prices, with administrative controls; and substitutes formal contract law by internal relations in which "hierarchy is its own court of ultimate appeal"<sup>61</sup>. He explains that the craft of internal coordinating mechanisms supplants the "autonomous" adaptation of the free market when authority relations have adaptive advantages over autonomy.

Schneider (2013) expands the concept of hierarchy to relations of ownership, labor, associations, vertical integration, as well as among firms, across sectors and national borders. To him, hierarchies replace relations that would be mediated by markets, coordination or networks in other varieties of capitalism. The distinction between hierarchical and market based relations is also present in the conceptual

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<sup>60</sup> As I have been referring generally to the system of water & sanitation.

<sup>61</sup> Williamson (1991), p. 274.

framework proposed by North, Wallis and Weingast (2009). They explain the importance of an open access order characterized by competition and impersonal credible commitments, typical of market relations, for adaptive efficiency in the pursuit of superior economic performance.

Bringing politics to the picture, the criterion of adaptive advantages of hierarchical authority over autonomy comes with the question whether power relations, within or beyond internal integration, block or enhance learning. In order to study such adaptive advantages in terms of the influence of power relations over learning fitness, agents are coded in two types: markets and hierarchies. Market agents are publicly traded companies that are more autonomous in relation to political authority and sensitive to the system of prices. Hierarchies are municipalities, states or state owned companies (except publicly traded) that operate mostly under political and bureaucratic authority. Needless to say that the agents are in hybrid positions located in the spectrum between market and hierarchy, each group closer to one of these poles. Notice that most of the publicly traded companies in water & sanitation have the state as the controlling shareholder, allowing some level of political influence. Nevertheless, they are also listed in BMF&BOVESPA, the Brazilian securities, commodities and futures exchange in São Paulo, in a segment committed to the highest level of corporate governance. Rather than a public vs. private dispute, the key is the level of autonomy vs. arbitrary influence. In my hypothesis, the arbitrariness seen in certain types of power relations might produce barriers to learning.

All these projects and agents experience very similar incentives and capabilities in terms of the internal policies of the Bank, including financial covenants and technical support. They are also submitted to the same legal system in the national level and regulations of the sector of water & sanitation. The subnational approach also improves the control for certain variables that would affect costs in the national level, such as inflation and exchange rate. Nonetheless, I use municipal HDI in order to control for subnational social and economic variations, i.e. as a proxy of the artifactual structure of capabilities and institutions developed in various regions where the projects take place<sup>62</sup>.

Given these preliminary observations and in order to provide statistical support to my choices of independent variables, I start studying to what extent the odds of market agents, simple investments and higher HDI to produce reflective learning are higher than those of hierarchies, complex projects and lower levels of development, respectively. The data is a panel of projects by dates that sum up to 9,525 registers, with learning and agent type as binary variables coded 1 for  $L_2$  and Market, Complexity measured by the log of the size of the investment<sup>63</sup> and municipal development as HDI. Since the dependent variable  $L_2$  is binary, I use a

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<sup>62</sup> As I pointed out in Chapter 3, there are plenty of empirical evidences of the relation between development, capabilities and institutions.

<sup>63</sup> Log is adequate because the size distribution has a very long upper tail and is quite skewed. In R\$ millions, the following descriptive statistics represents all the projects that have been in the sample, regardless of for how long: mean 54; standard deviation 207; minimum 0.300; maximum 2,902; median 17; first quartile 7.5; third quartile 46.

logit model to estimate the coefficients ( $B$ )<sup>64</sup>. In this case coefficients are in log odds and the standard procedure of exponentiation ( $e^B$ ) results in the odds ratios.

Table 4.1 displays the estimates, standard errors ( $SE$ ) and the confidence intervals ( $CI$ ) for  $B$ . The interpretation of  $e^B$  is straightforward for Market: the odds of Market agents to learn reflectively are 88% higher than Hierarchies. For Complexity, with base 10 log of size the estimate is that for a tenfold increase in the size of the investment, from R\$ 10 million to R\$ 100 million for example, there is a 56% decrease in the odds of reflective learning to be produced ( $1.00 - 0.44 = 0.56$ ). The results are the expected for Market and Complexity, but for HDI the marginal effect found is not statistically significant.

**Table 4.1 – Results of the logit model for the dependent variable  $L_2$**

	$B$	$SE$	$e^B$	$CI$	
				2.5%	97.5%
<b>Intercept</b>	5.93***	0.73	375.23	4.49	7.36
<b>Market</b>	0.63***	0.08	1.88	0.48	0.79
<b>Complexity</b>	- 0.82***	0.07	0.44	- 0.95	- 0.68
<b>HDI</b>	- 0.18	0.84	0.84	- 1.83	1.47

Significance: 0 '\*\*\*\*' 0.001 '\*\*\*' 0.01 '\*\*' 0.05 '.' 0.1 '.' 1.

The results confirm the importance of market relations and simplicity for learning. Moreover, the dataset is quite rich, allowing not only the study of the dynamics of learning through time, but also a research design with explanatory variables coded

<sup>64</sup> In terms of the *pglm* package in R:  $L_2 \sim Market + LogSize + HDI$ . Further details are in the Appendix 8.1.

by agent type and project complexity. One could add further techniques to improve the model specification, but the results would remain more a statistical support to the choices of variables than to the hypotheses of the research. My hypotheses require a method that admits the observation of the dynamics in which the variables of study are involved and an approach for tracing the intervening barriers to learning that affect such dynamics. Chapter 5 is about the former and Chapter 6 on the latter.

## **5. Path Dependence in Adaptive Development**

The study of path dependence in adaptive development requires a method to assess the dynamics of learning. Project teams organize and reorganize solutions attempting to comply with the requirements that will open access to funding for their planned investments. Beyond individuals and organizations, reflective and unreflective learning take place in this process of adaptation gaining and losing shares as time goes by in waves of reorganization spreading throughout the system. This dynamics of shares of learning types changing through time is the center of interest of this research. Studying such dynamics, I expect to find the underlying patterns of path dependence to learning types.

As discussed in Section 2.3, development is path dependent insofar the future depends on its past trajectory. It is a quite simple and somewhat obvious statement that becomes more interesting when one qualifies the kind of path dependency under the spotlight. This research focuses on path dependent patterns of development in virtuous and vicious cycles, with special attention to the processes locked in states of unreflective learning that defines the latter. In such situation, society remains stuck to old problems without the ability to unlock prosperity with reflective learning. With regard to the observed data, agents remain unable to deliver development in the form of social goods.

In this chapter I study two hypotheses: (i) learning is a source of path dependence in the process of development; (ii) hierarchical power relations and complexity



reduce the fitness of reflective learning. In the empirical analysis that follows I show how the estimate of the fitnesses of learning types unveils a pattern locked in unreflective learning, different from the optimistic picture seen in Section 4.3. I introduce the concepts and the approach of Evolutionary Game Theory to estimate fitness as presented by Friedman and Sinervo (2016) and, in order to explore hypothesis (i), I apply to our learning types the techniques these authors used in the study of three lizards' mating strategies. In sequence, I study hypothesis (ii) submitting the data to the same approach with the addition of municipal development, agent types and complexity as explanatory variables of the learning dynamics.

### **5.1. Learning Fitness and Path Dependent Dynamics**

Sinervo and Lively (1996) found an interesting “rock-paper-scissors” dynamics studying three mating strategies of side-blotched lizards (*Uta stansburiana*). They observe that males with orange throats acquire large territories with aggressive attempts to exclude other males, an effective strategy against the blue throats but one that fails against the yellow. The yellow-throated lizard mimics female behavior and sneaks in to copulate, while the orange males are fighting. The blue males, in their turn, lose territory to the orange strategy, but cooperate to other blue male neighbors to defend adjacent territories against the cheating yellow strategy. Just like the old game, each strategy wins against one and loses against the other.

Friedman and Sinervo (2016) confirm such dynamics estimating a 3 x 3 payoff matrix with the data of shares of the three lizards morphs described, based on annual hand counts. They find nine fitness (payoff) values  $W_{ij}$  ( $i, j =$  orange, yellow, blue) that account for the observed share dynamics. My idea is to apply this approach to study the dynamics of our three learning types. Since learning shares change in a monthly basis without complications of sexual dynamics, such as overlapping generations, I consider time discrete. I also treat population as constant, for the reasons described in section 4.3. This simplifies the analysis allowing the implementation of the approach in two steps: first, using the data set to estimate the fitnesses of learning types and, second, simulating the dynamics of learning types for various initial states. The fitness matrix will show the relative advantage of each learning type over the others that produces the dynamics of the system. In the analysis of such dynamics, the main questions are where are the shares moving to and how. Does the system reach a steady state in which the shares of all learning types remain constant over time? How fast distinct initial states move to these steady states?

In evolutionary theory, fitness is the ability of a trait, species, meme or, more generally, strategy to gain shares. Thinking of learning types ( $L_i$ ) gaining and losing shares in a process of evolution, fitness ( $W_i$ ) can be defined in discrete time as:

$$L_i(t + 1) = \frac{W_i}{\bar{W}} L_i(t), \quad i = 0, 1, 2,$$

where  $\bar{W} = \sum_{i=0}^2 L_i W_i$  is the average fitness.

Widely used in evolutionary processes, this equation is known as replicator dynamics and means that the share changes according to relative fitness. If ( $W_i$ ) is greater than the average fitness, the shares of learning type  $i$  will increase. If it is less than average, shares will decrease. In this sense, fitness is the growth rate of shares. The fitness of each learning type  $W_i$  at a given state  $\mathbf{L} = (L_0, L_1, L_2)$  is weighted by the respective shares<sup>65</sup>:

$$W_0 = L_0 W_{00} + L_1 W_{01} + L_2 W_{02}$$

$$W_1 = L_0 W_{10} + L_1 W_{11} + L_2 W_{12}$$

$$W_2 = L_0 W_{20} + L_1 W_{21} + L_2 W_{22}$$

By definition, shares are non-negative ( $L_i \geq 0$ ) and sum to  $\sum_{i=0}^2 L_i = 1$  for each time  $t$ . Calculating the proportion of each learning type for each month from the panel data, I produce a 3 x 58 vector of shares with three learning types changing shares for 58 months. The task now is to estimate the 3 x 3 fitness matrix  $W_{ij}$  ( $i, j = 0,1,2$ ) that is most likely to produce such vector of shares, in the form of:

$$\mathbf{W} = \begin{pmatrix} W_{00} & W_{01} & W_{02} \\ W_{10} & W_{11} & W_{12} \\ W_{20} & W_{21} & W_{22} \end{pmatrix}$$

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<sup>65</sup> Friedman and Sinervo (2006), p. 54.

$W_{ij}$  represents the fitness of learning type  $i$  disputing in a world of learning type  $j$ . One of the most important differences between traditional and evolutionary games is that the latter relaxes the assumption of rationality. So, I invite the reader to avoid the temptation of thinking of the encounter between learning types as a moment of calculated choice. Individual minds are only part of the learning process, only media through which learning waves pass by. Even though  $L_2$  is a type of reflective design, its prevalence after each encounter with other types is not a product of rationality whatsoever. It is a process of adaptation in which distinct types of reorganization may occur depending on how ambiguous, complex and defensive the system is. Since we seldom realize these barriers to learning, we may reflect about the problems we solve, but not quite about the learning type we follow.

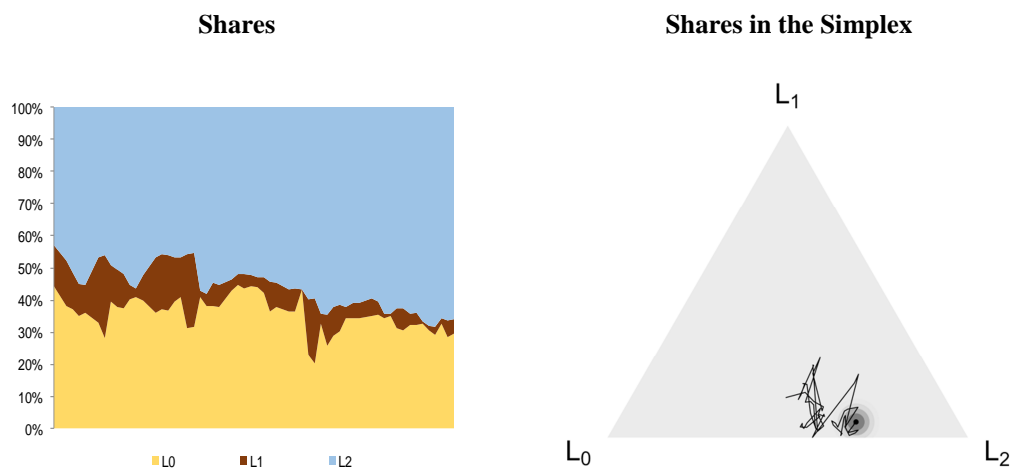
The state of a system is the vector of shares  $\mathbf{L} = (L_0, L_1, L_2)$  that can be represented by a point in the 2-simplex. A 2-simplex is a two-dimensional equilateral triangle whose corners are the states in which everyone uses the same learning type. The opposite edge of each learning type represents the states in which only the other two learning types are at play. The simplex in Figure 5.1 shows the dynamics of the system with the same data of the shares chart<sup>66</sup> on the left. An appealing way to think about the simplex is as a field of attraction: imagine each corner, representing each learning type, performing a force of attraction at time  $t$ . The simplex in the figure shows the dynamics of a system in

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<sup>66</sup> “Shares” or “Data” charts always with yellow  $L_0$  in the bottom, red  $L_1$  in the middle and blue  $L_2$  on top. Except when mentioned otherwise, horizontal axis always refers to 58 months.

which the attraction of reflective learning seems to be resulting in a relatively successful state. The path is a move from the center bottom to the right, away from  $L_0$  and  $L_1$ , getting closer to  $L_2$ , from the state  $(0.44, 0.13, 0.43)$  to  $(0.30, 0.04, 0.66)$ . This means  $L_2$  increases from 43% to 66%. Observe this is not yet any sort of steady state or equilibrium. The charts represent the whole data set, with its real initial ( $t = 0$ ) and final ( $t = 58$ ) shares.

**Figure 5.1 – Learning Shares in the Simplex**



Estimating the fitness matrix, I will be able to simulate the dynamics of the system for any set of initial values and produce a similar simplex with a nice visual representation of the shares of learning types moving to steady states. In order to do so, I follow Friedman and Sinervo (2016) and add the Dirichlet distribution to the discrete time replicator equation, a tailor-made distribution with density zero outside the simplex. Hence, the discrete time replicator equation is the deterministic part of the model,

$$Z_i(t) = \frac{W_i(t-1)}{\bar{W}(t-1)} L_i(t-1),$$

while the Dirichlet distribution specifies the stochastic part:  $L_i(t) \sim \text{Dir}(NZ_i(t))$ .

In this sense,  $L_i(t)$  is a random variable with mean  $Z_i(t)$  and variance  $\frac{Z_i(t)[1-Z_i(t)]}{N+1}$

on the simplex  $\mathcal{S} = \{(L_0, L_1, L_2) \in \mathbb{R}^3: L_i \geq 0, \sum_i L_i = 1\}$ .

The model is, then, the conditional probability based on the difference equation we have, i.e. the replicator dynamics, with the Dirichlet distribution representing our prior knowledge about the parameters. Given the previous state  $L(t-1)$ , the conditional density of the current state is

$$f(L(t)|L(t-1)) = \frac{\Gamma(N)}{\prod_{i=0}^2 \Gamma(NZ_i(t))} \prod_{i=0}^2 L_i(t)^{NZ_i(t)-1}.$$

The final step is finding the conditional log-likelihood function for the maximum likelihood estimation procedure by summing the log of the conditional density for the whole period, i.e. from  $t_1$  to  $t_{58}$  (denoted by  $T$ )<sup>67</sup>:

$$\ln \ell = T \ln \Gamma(N) + \sum_{t=1}^T \sum_{i=0}^2 [-\ln \Gamma(NZ_i(t)) + \ln L_i(t) \cdot (NZ_i(t) - 1)].$$

Fitnesses in the discrete replicator can't be negative<sup>68</sup>, so each entry satisfies  $W_{ij} \geq 0$  and, in order to solve a problem of indeterminacy, Friedman, Paranjpe,

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<sup>67</sup> See Appendix for further details about the model and the estimation procedure. See Friedman and Sinervo (2006), p. 91 for the original model.

Magnani and Sinervo (2016) suggest the normalization of the original matrix, imposing the constraint  $\sum_i \sum_j W_{ij} = 1$ . Given these constraints, I use a numerical algorithm to find the parameter vector that maximizes the likelihood of the observed data, which is the maximum likelihood estimate for the fitness matrix. Table 5.1 presents the results with bootstrapped standard errors in parentheses.

*Table 5.1 – Normalized Fitness Matrix  $W$*

	$L_0$	$L_1$	$L_2$
$L_0$	0,0000 (0,0173)	0,3994 (0,0551)	0,0000 (0,0471)
$L_1$	0,0408 (0,0285)	0,1618 (0,0596)	0,0000 (0,0491)
$L_2$	0,0000 (0,0236)	0,3979 (0,0574)	0,0001 (0,0293)

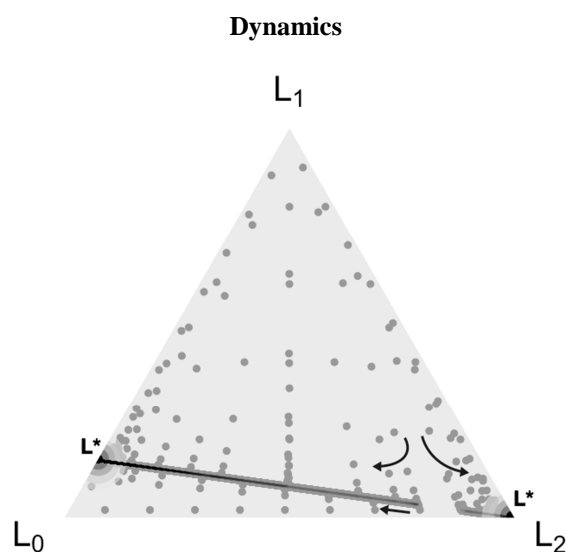
Remember we are playing the rows against the columns. In the world of the column  $L_0$ ,  $L_1$  has the higher fitness. The other way around is also true:  $L_0$  wins when everyone else is playing  $L_1$ . These are situations of negative frequency dependence, or decreasing returns to scale. This means  $L_1$  won't have a sustainable growth, because it will lose fitness while gaining shares. Notice that if  $L_1$  starts to blossom,  $L_0$  will strike back with the higher fitness of the game.  $L_2$  still gains shares against  $L_1$ , slower than  $L_0$  though, and might be a case of increasing returns with a very low advantage. The bottom line is that the fitness advantage of  $L_0$  makes the system path dependent to unreflective learning. The simplex geometry with the simulation will help us visualize such dynamics.

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<sup>68</sup> The minimum number of “descendants” in the next generation is zero.

With the fitness matrix ready, I can go further and simulate the dynamics of the system for several months and various initial share values. Given any initial shares  $\mathbf{L}(0) = (L_0(0), L_1(0), L_2(0))$ , I can use the discrete time replicator dynamics to calculate the shares of learning types through time. Figure 5.2 shows 37 initial states distributed around the simplex<sup>69</sup> and a projection of 50 years from a “fair” initial state  $\mathbf{L} = (\frac{1}{3}, \frac{1}{3}, \frac{1}{3})$ .

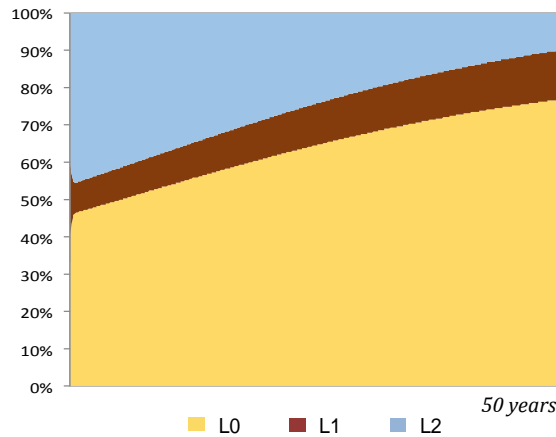
*Figure 5.2 – Dynamics of the Total Portfolio of Projects*



<sup>69</sup> I use the *ggtern* software package in R to produce the simplex diagrams.



### “Fair” Game



Except for a small region far away from  $L_0$  and closer to the corner  $L_2$ , in which a few initial states move to the steady state of  $L^* = (0, 0, 1)$ , from any initial state the system falls onto a stream moving to the edge between  $L_0$  and  $L_1$ , into the unreflective learning world of the steady state  $L^* = (0.85, 0.15, 0)$ . The sparse points mean that from any initial state the system moves fast to the stream. The higher density of this line is the result of a lower speed flow, consistent with the decreasing returns seen in the matrix. The simplex provides a visual representation of the dynamics of the microgenesis of development, as well as an argument for hypothesis (i). Learning is a source of path dependence in the process of development because for the great majority of initial states the system is attracted to unreflective learning. In other words, the system formed by the object of this research, i.e. the production of social goods, is trapped in a path dependent pattern of unreflective learning. The relatively successful picture of the real data seen in Figure 5.1 can be explained by the long time the system takes to reach the steady state of 85% of unreflective learning. The fair game in Figure 5.2, for instance,

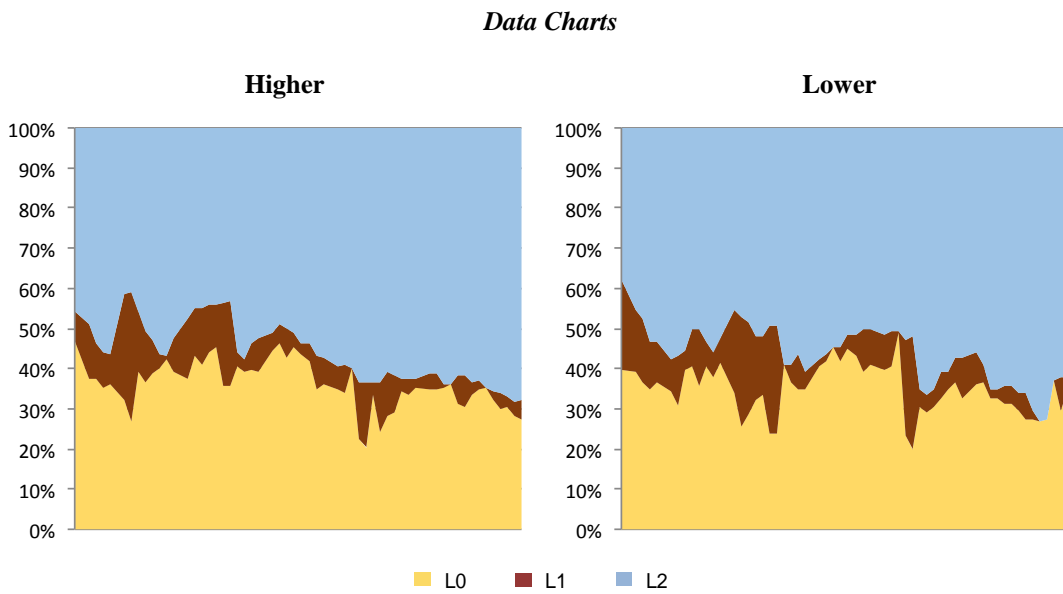
reaches 50% of unreflective learning in five years, 77% in 50 years and would take one century to reach the steady state. Notice the decreasing returns looking at the yellow  $L_0$  curve at the bottom of the fair game chart: the larger the share, the longer it takes to grow.

Since the dynamics unveils development locked-in a trap of unreflective learning, the question comes down to what can be done to unlock prosperity. First, let's see the dynamics of adaptive learning in two groups, divided by levels of development. They represent the artifactual structure of capabilities and institutions of the environment in which adaptive learning is taking place. Where municipal development is higher, the theory would predict higher adaptive efficiency. As explained in section 4.3, all categories are divided in two levels because otherwise the number of observations would be too small in certain combinations of variables. For municipal development the level is Higher for municipalities where  $HDI \geq 0.736$ .

Reflective learning  $L_2$ , in blue, increases approximately 20% in both higher and lower levels, as seen in the data charts in Figure 5.3. On the other hand, the yellow  $L_0$  was persistent in municipalities with lower development, decreasing only 4%, while in the higher group it plunged from 47% to 27% during the five years of the available data. The fitness matrices produced by the data follow the structure of the matrix for the whole data set, with decreasing returns to scale. The dynamics flow as predicted by the theory: where development is higher, the system runs to the steady state of reflective learning  $L^* = (0.00, 0.00, 1.00)$ ; where development

is lower, the system converges to 86% of unreflective learning. The dense black line in the former indicates, however, that it would take a very long time for the system to converge to 100% of  $L_2$ .

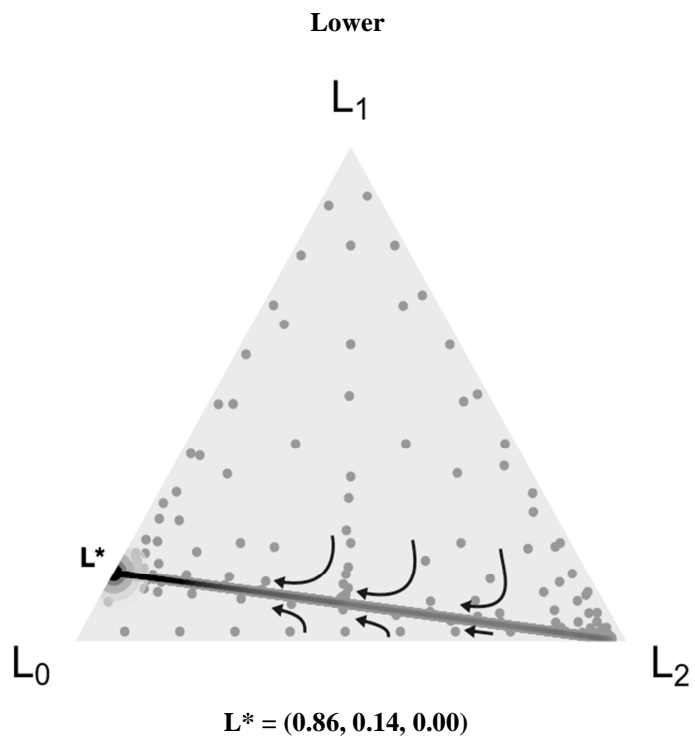
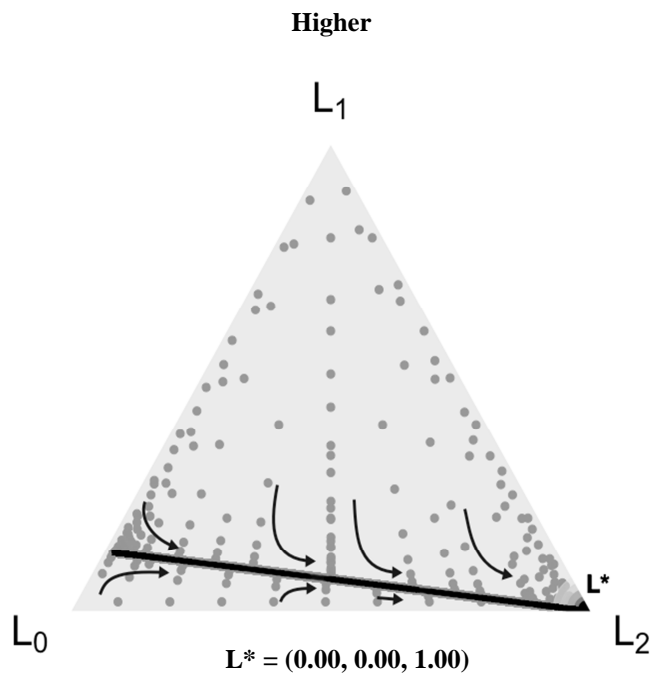
**Figure 5.3 – Learning Dynamics by Municipal Development**



*Fitness Matrices W*

	<b>Higher</b>			<b>Lower</b>		
	$L_0$	$L_1$	$L_2$	$L_0$	$L_1$	$L_2$
$L_0$	0,0000 (0,0159)	0,3892 (0,0366)	0,0000 (0,0252)	0,0000 (0,0137)	0,4286 (0,0406)	0,0000 (0,0262)
$L_1$	0,0288 (0,0294)	0,1926 (0,0625)	0,0000 (0,0277)	0,0535 (0,0271)	0,0979 (0,0402)	0,0000 (0,0286)
$L_2$	0,0000 (0,0199)	0,3893 (0,0407)	0,0000 (0,0131)	0,0001 (0,0222)	0,4200 (0,0411)	0,0000 (0,0050)

*Dynamics*



One may observe the concentration of fitness in the  $L_1$  column as a recurrent pattern. In fact, it is in the  $L_1$  world that most of the “action” is going on. The struggle is mostly between upgrading to  $L_2$  or falling back to  $L_0$ , what in the theory would mean developing to a “double loop” learning type or not. Because the fitnesses of  $L_0$  and  $L_2$  in the  $L_1$  column of the Higher matrix are so close, one could also inquire what would happen if  $L_0$  were slightly higher instead. In this case, the steady state would be on the opposite edge and the system would converge to unreflective learning, likewise in the simplex of the lower group. However, it would take much longer, centuries for higher development versus decades for the lower, opening much more opportunities for reflective learning in the long run. In this sense, the dynamics would still confirm the statement that adaptive efficiency, measured by reflective learning, is higher where the artifactual structure, measured by municipal development, is better. I don’t want to be pessimistic about the prospects of the supply of water & sanitation in Brazil, but these dynamics also confirm the vicious cycle of lower development and unreflective learning of the analytical model I suggested. The missing links capable to reverse this cycle are the barriers to learning produced by power relations and complexity, a set of variables I will start to study in the following sections.

## **5.2. Power Relations, Complexity and Path Dependence**

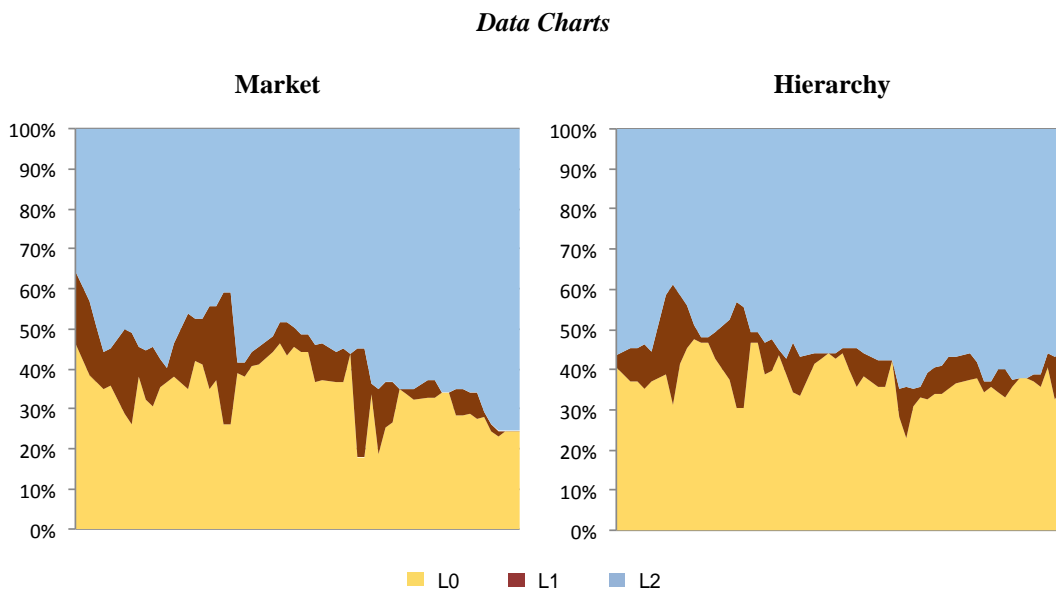
We’ve seen that in less developed environments adaptive efficiency is lower. The theory explains that the artifactual structure in those cases has been unable to

support society towards prosperity by an adaptive learning process. Through the lens of the proposed analytical model, capabilities and institutions have been unable to unblock the barriers to learning. The second hypothesis is that hierarchical power relations and complexity increase path dependence to unreflective learning. Nourishing misperceptions, ambiguities and defensiveness, hierarchies and complexity block the rise of reflective learning in vicious cycles of underdevelopment. In order to study this hypothesis, I analyze the dynamics of adaptive learning by agent types and complexity. I also control for municipal development in an attempt to improve this research design. I observe the differences of the dynamics between market and hierarchies, as well as between simple and complex groups, when development is lower or higher. As defined in section 4.3, Market agents are publicly traded companies that are less susceptible to political arbitrariness, while Hierarchies are municipalities, states or state owned companies (except publicly traded) more influenced by political and bureaucratic authority. In terms of complexity, simple projects are defined as investments of less than R\$ 30 million. At this point, I have two questions in mind: are market relations or simpler projects able to unlock reflective learning? If not, do they at least explain lower path dependence to unreflective learning, producing dynamics in which reflective learning would have more opportunities to flourish?

The data charts in Figure 5.4 show market relations performing better in the period, increasing  $L_2$  from 35% to 75%, while hierarchies lose and recover shares to keep  $L_2$  in the same 56%. The underlying fitnesses produce dynamics that don't

look so different at a first sight. Nevertheless, one interesting thing about looking at the dynamics of change is that the analysis is not simply about equilibrium. As important as where the system is going is the observation of how fast the stream is moving.

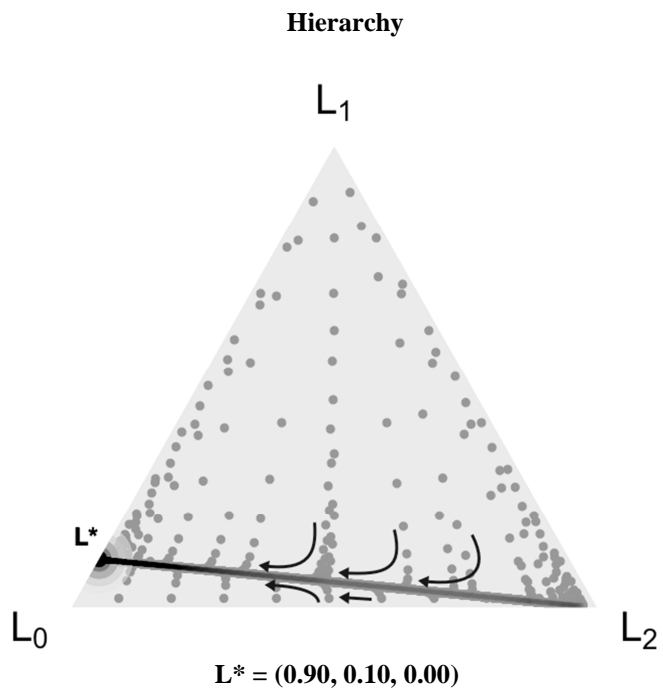
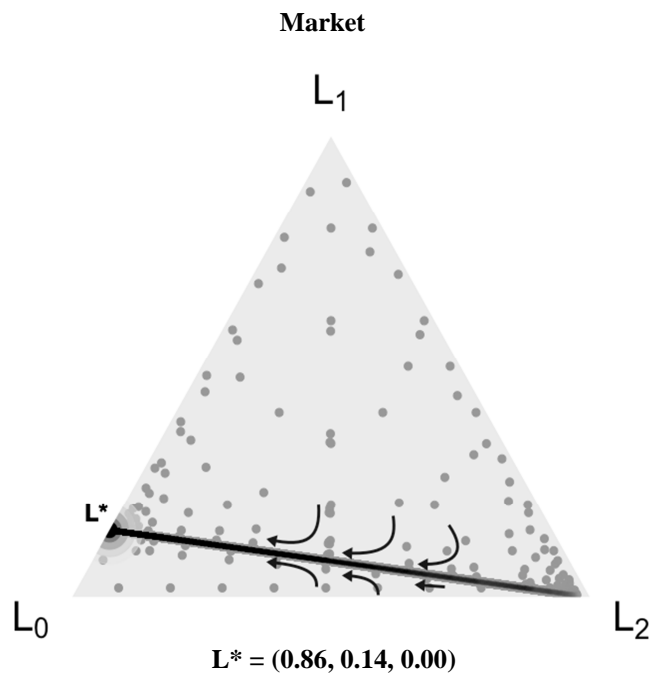
**Figure 5.4 – Learning Data, Fitness and Dynamics by Agent Type**



**Fitness Matrices W**

	<b>Market</b>			<b>Hierarchy</b>		
	$L_0$	$L_1$	$L_2$	$L_0$	$L_1$	$L_2$
$L_0$	0,0000 (0,0107)	0,4108 (0,0692)	0,0000 (0,0548)	$L_0$	0,0000 (0,0132)	0,3905 (0,0514)
$L_1$	0,0467 (0,0267)	0,1342 (0,0470)	0,0000 (0,0540)	$L_1$	0,0217 (0,0283)	0,2034 (0,0699)
$L_2$	0,0001 (0,0229)	0,4082 (0,0572)	0,0000 (0,0261)	$L_2$	0,0000 (0,0211)	0,3843 (0,0557)

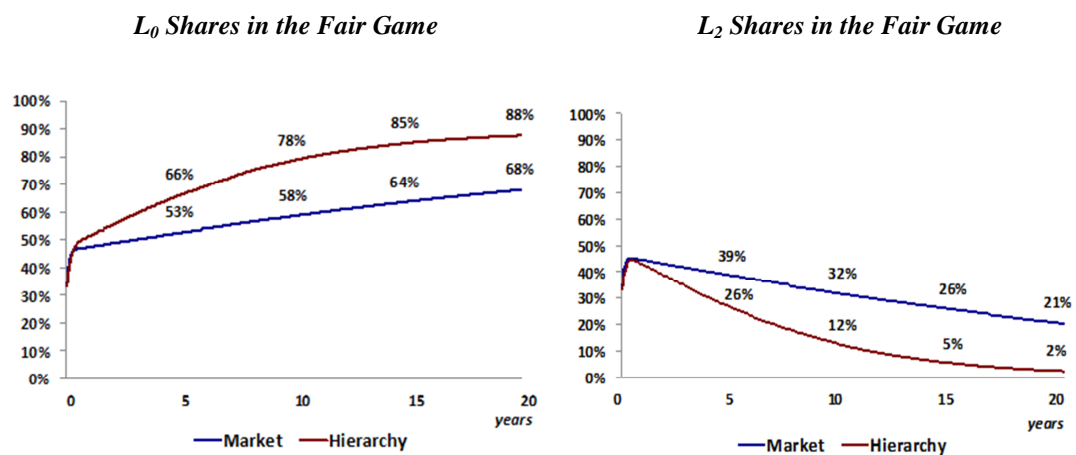
*Dynamics*





Market relations have a small advantage over hierarchies in terms of the steady states they aim to: the former reaches  $L^* = (0.86, 0.14, 0.00)$  and the latter  $L^* = (0.90, 0.10, 0.00)$ . However, path dependence to unreflective learning is stronger when relations are hierarchical because the system converges faster to such unfavorable steady state. In a fair game, for instance, with market relations the system reaches 53% of unreflective learning in five years and 58% in 10 years. On the other hand, when relations are hierarchical,  $L_0$  increases to 66% and 78% in five and 10 years, respectively. Figure 5.5 shows this comparison between agent types for unreflective and reflective learning during 20 years.

*Figure 5.5 – Comparing Path Dependence in Market and Hierarchical Relations*



When power is based on market relations, there is more room for a longer time for reflective learning, with more opportunities for turning a vicious cycle into a virtuous cycle. In the fair game, while in 20 years  $L_2$  falls to 2% in hierarchies, market relations are still struggling to adapt reflectively in the level of 21%. This relative advantage is smaller when the initial state is closer to  $L_0$  and larger when

it's farther, but there is always an advantage of market over hierarchy in terms of the area below the curve. The larger the area, the higher the path dependence to learning, because it means the system spends more time closer to  $L_i(t)$ <sup>70</sup>.

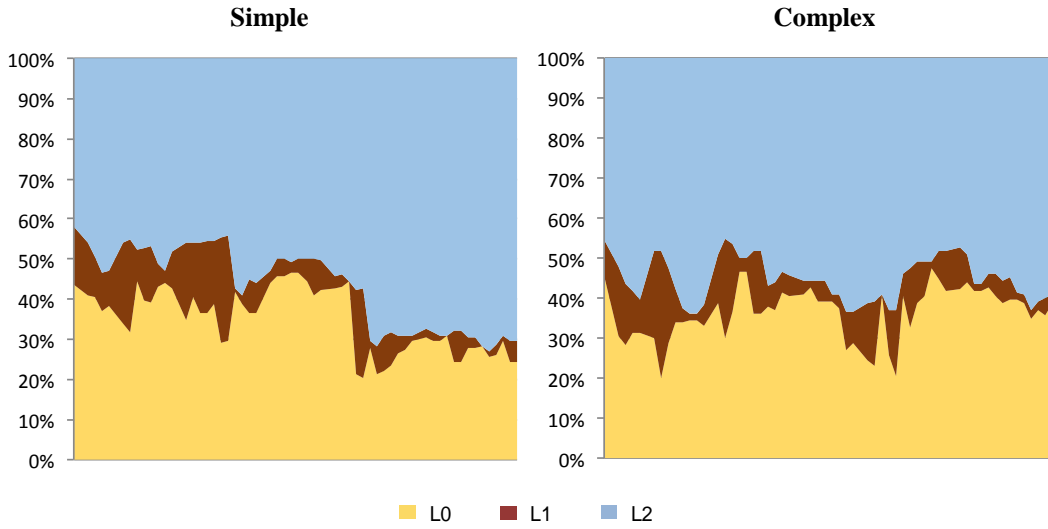
Complexity is the second explanatory variable. The available data supports the hypothesis again, as seen in Figure 5.6, which compares the simple and the complex levels. In the data chart of the former,  $L_2$  soars from 42% to 70%, while in the latter it increases from 45% to 59% with more volatility. There are decreasing returns in the fitness matrices again, but the dynamics of the group in which complexity is lower is very different from the dynamics we've seen so far. "Keeping it simple" results in a steady state much closer to reflective learning (0.37, 0.09, 0.54) than the 85% of  $L_0$  of those working in complexity. The system also converges faster when complexity is lower. Notice the black density of the slow stream to the steady state in the simplex of higher complexity. While market relations are only less path dependent than hierarchies, lower complexity seems to really break the vicious cycle, reducing the barriers to reflective learning. However, are both statements still true regardless of the level of development in which they are examined?

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<sup>70</sup> One can think of path dependence to any learning type in terms of  $\int_0^t L_i(t)dt$ , for any initial state  $\mathbf{L}$ .

Figure 5.6 – Learning Data, Fitness and Dynamics by Complexity

Data Charts

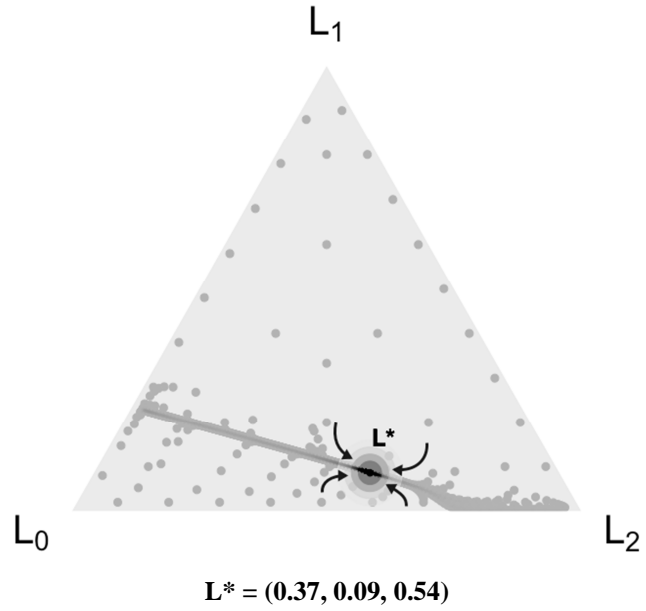


Fitness Matrices  $W$

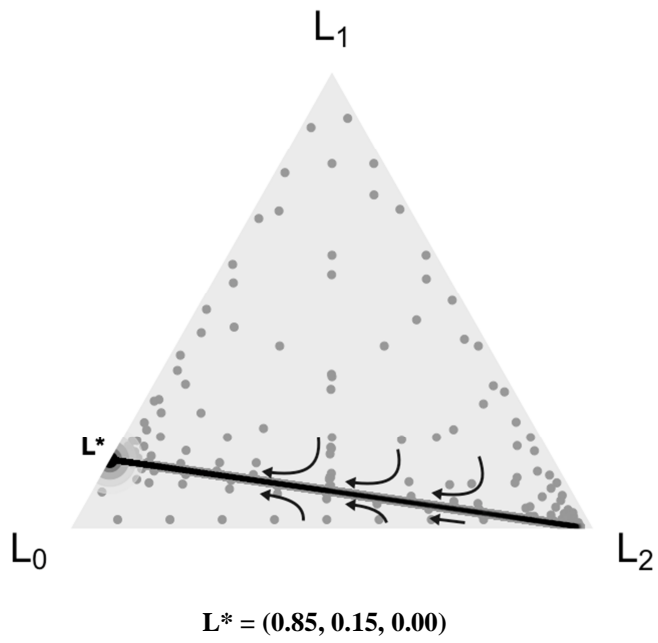
Simple				Complex			
	$L_0$	$L_1$	$L_2$		$L_0$	$L_1$	$L_2$
$L_0$	0,0479 (0,0149)	0,3693 (0,0380)	0,0189 (0,0258)	$L_0$	0,0000 (0,0052)	0,4137 (0,0489)	0,0000 (0,0367)
$L_1$	0,1617 (0,0302)	0,0000 (0,0473)	0,0000 (0,0254)	$L_1$	0,0515 (0,0196)	0,1235 (0,0479)	0,0000 (0,0371)
$L_2$	0,0723 (0,0232)	0,3199 (0,0594)	0,0100 (0,0148)	$L_2$	0,0001 (0,0113)	0,4112 (0,0471)	0,0000 (0,0167)

*Dynamics*

**Simple**

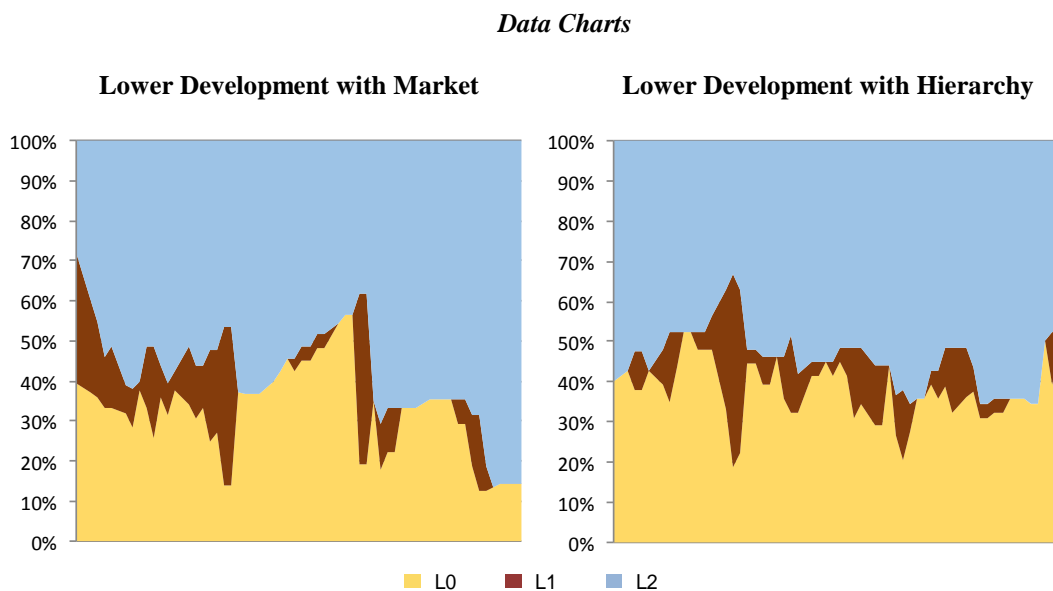


**Complex**



The empirical evidence seems to confirm the hypotheses in study, but we still need to control for the effect of municipal development. The whole effort of studying the political economy of development is motivated by the search of a way to move less developed societies to prosperity. Hence, I start assessing the effect of market relations and simple projects in a group of municipalities where development is lower.

**Figure 5.7 – Control for Lower Municipal Development: Agent Types**



**Fitness Matrices W**

**Lower Development with Market**

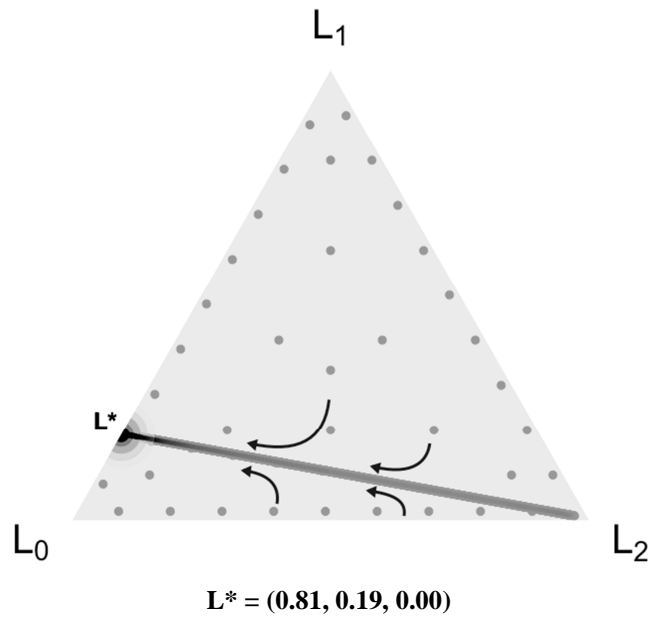
	$L_0$	$L_1$	$L_2$
$L_0$	0,0003 (0,0022)	0,4540 (0,0613)	0,0001 (0,0553)
$L_1$	0,1074 (0,0166)	0,0000 (0,0105)	0,0021 (0,0499)
$L_2$	0,0005 (0,0107)	0,4356 (0,0531)	0,0000 (0,0131)

**Lower Development with Hierarchy**

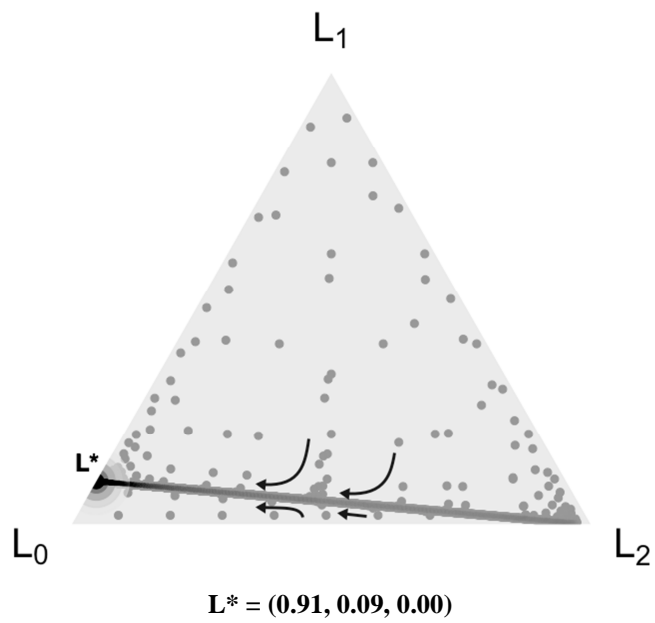
	$L_0$	$L_1$	$L_2$
$L_0$	0,0000 (0,0093)	0,4299 (0,0646)	0,0000 (0,0377)
$L_1$	0,0322 (0,0332)	0,1231 (0,0425)	0,0000 (0,0416)
$L_2$	0,0000 (0,0263)	0,4148 (0,0610)	0,0000 (0,0165)

*Dynamics*

**Lower Development with Market**



**Lower Development with Hierarchy**

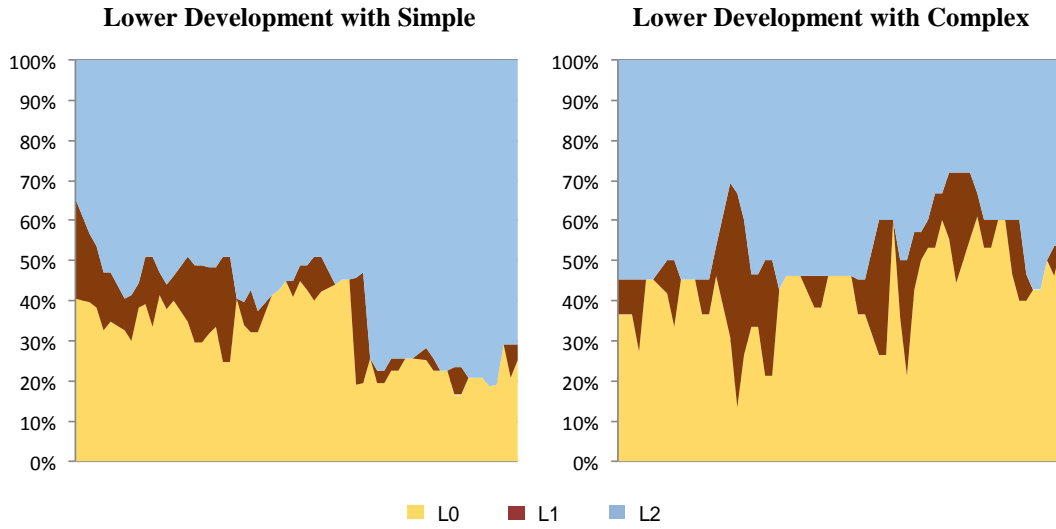


The difference between the charts with the real data in Figure 5.7 is striking. With market relations, reflective learning is skyrocketing from 27% to 86%, while with hierarchical relations it decreases from 60% to 48%. Even though the fitness matrices produce dynamics that are not that distinct, market still has an advantage over hierarchies. In five years  $L_0$  for the fair game is 7% higher in hierarchies and after 10 years it approaches 10%, the difference observed when both reach the steady states.

The same analysis applies to the real data on regard to the level of complexity. The performance of simplicity in municipalities with lower development is remarkably better compared to complex projects, as seen in Figure 5.8. The result of the dynamics, however, is unexpected. After such an interesting steady state for simple projects with the whole data, the dynamics turns out to be quite similar in lower development, regardless of the level of complexity. The steady states are again on the edge between  $L_0$  and  $L_1$ , but very close to each other. The flow is also similar, with a small advantage of simple over complex that spreads the maximum of 6% in five years, in the example of the fair game. The sparse points in the simple simplex mean the system falls faster onto the stream, but the slightly higher density of the line shows the simple system running slower than the complex once the states reach the stream.

Figure 5.8 – Control for Lower Municipal Development: Complexity

Data Charts



Fitness Matrices W

Lower Development with Simple

	$L_0$	$L_1$	$L_2$
$L_0$	0,0002 (0,0047)	0,4650 (0,0477)	0,0001 (0,0324)
$L_1$	0,0848 (0,0172)	0,0000 (0,0066)	0,0000 (0,0366)
$L_2$	0,0003 (0,0175)	0,4497 (0,0434)	0,0000 (0,0030)

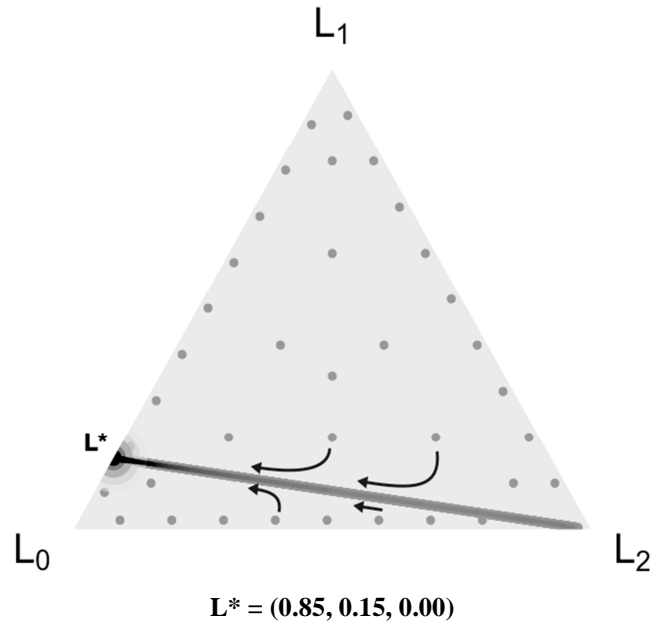
Lower Development with Complex

	$L_0$	$L_1$	$L_2$
$L_0$	0,0000 (0,0043)	0,4532 (0,0512)	0,0001 (0,0250)
$L_1$	0,0596 (0,0221)	0,0525 (0,0235)	0,0000 (0,0331)
$L_2$	0,0001 (0,0122)	0,4344 (0,0474)	0,0000 (0,0050)

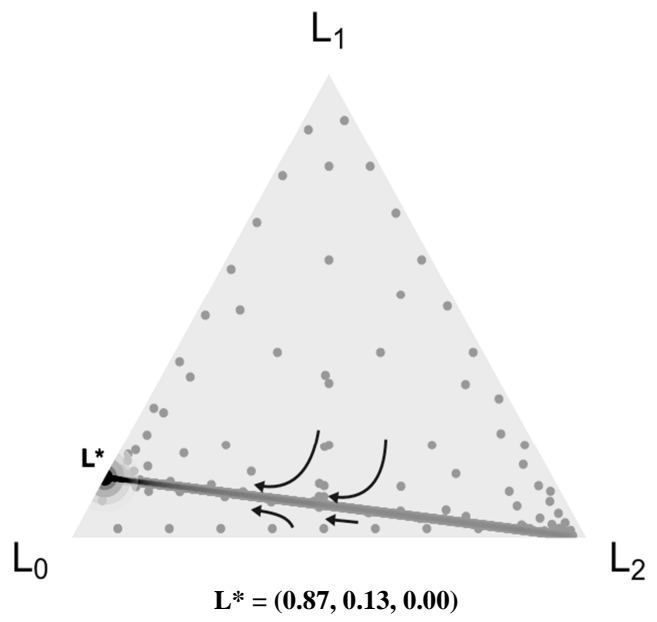


*Dynamics*

**Lower Development with Simple**

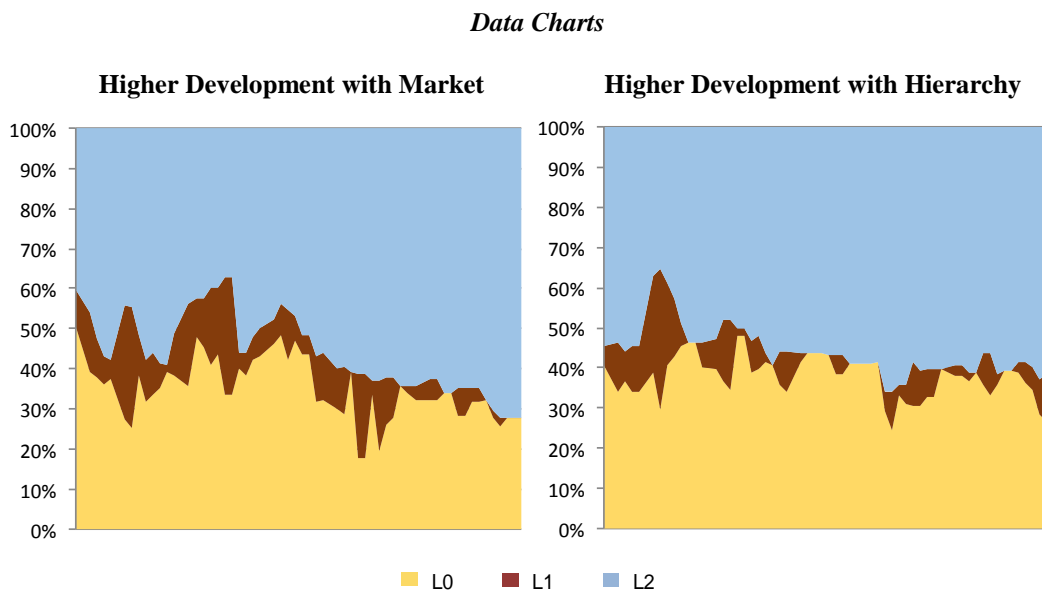


**Lower Development with Complex**



If one wishes to prescribe public policies with the intention of leveraging less developed regions into prosperity, it seems so far that the vicious cycle predicted by the analytical model holds as a powerful obstacle. While in the data charts market and simple perform much better, the dynamics show that, even though hierarchies and higher complexity are still the worst scenarios, moving away from the trap of unreflective learning is difficult when the artifactual structure does not contribute. Studying the group with higher development by agent type and complexity will shed light on this argument.

**Figure 5.9 – Control for Higher Municipal Development: Agent Types**



*Fitness Matrices W*

**Higher Development with Market**

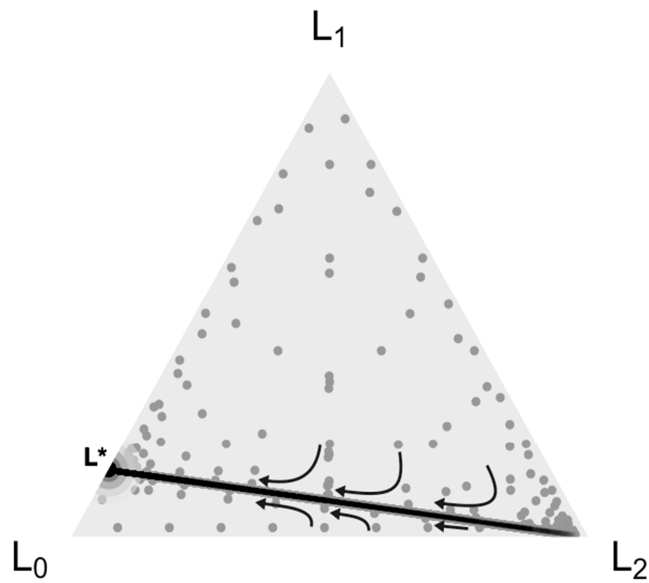
	$L_0$	$L_1$	$L_2$
$L_0$	0,0000 (0,0069)	0,4126 (0,0654)	0,0000 (0,0555)
$L_1$	0,0473 (0,0227)	0,1293 (0,0445)	0,0000 (0,0649)
$L_2$	0,0001 (0,0147)	0,4107 (0,0665)	0,0000 (0,0208)

**Higher Development with Hierarchy**

	$L_0$	$L_1$	$L_2$
$L_0$	0,0000 (0,0215)	0,3969 (0,0569)	0,0000 (0,0205)
$L_1$	0,0000 (0,0360)	0,2022 (0,0588)	0,0090 (0,0248)
$L_2$	0,0000 (0,0322)	0,3919 (0,0548)	0,0000 (0,0102)

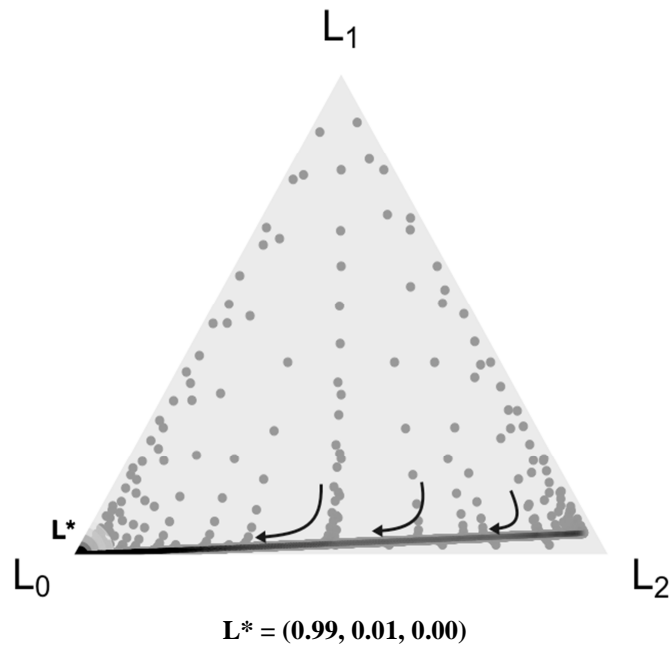
*Dynamics*

**Higher Development with Market**



$L^* = (0.86, 0.14, 0.00)$

### Higher Development with Hierarchy

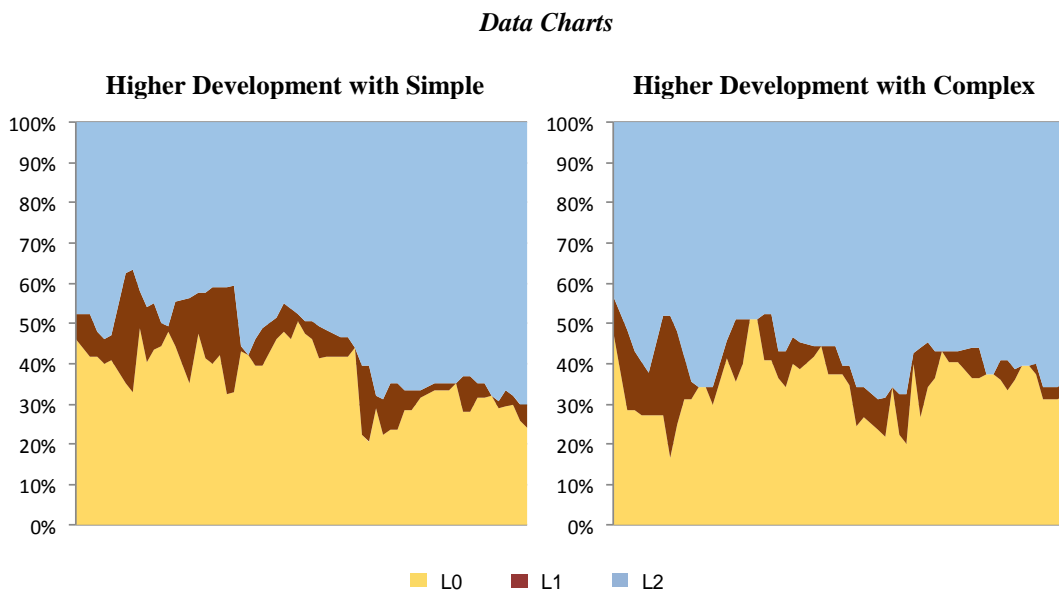


The available data of the 58 months in Figure 5.9 displays again market relations performing better than hierarchies, increasing from 40% to 72%, compared to a lower range from 54% to 61% of the latter. Market is less attracted to  $L_0$  in the simplex as well, converging to the steady state  $(0.86, 0.14, 0.00)$ , while hierarchies run faster to a world of 99% of unreflective learning. Hence, when development is higher, the artifactual structure improves the adaptive ability of market relations. These market based power relations reduce barriers to learning and, consequently, weaken the path dependence of the system to unreflective learning.

In environments of higher development levels of complexity also have a remarkable difference in terms of their dynamics, as seen in Figure 5.10.

Regarding the available data,  $L_2$  increases a bit more than 20% in both cases, but  $L_0$  drops 22% in the simple and 15% in the complex. The results for the dynamics are more salient as a support to the hypothesis: the simple simplex converges very fast to (0.39, 0.08, 0.32), while complexity falls onto 92% of unreflective learning.

**Figure 5.10 – Control for Higher Municipal Development: Complexity**



**Fitness Matrices  $W$**

**Higher Development with Simple**

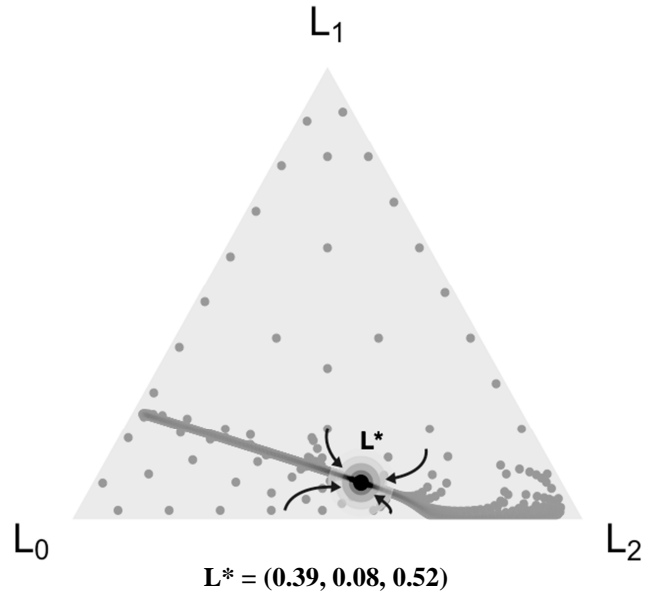
	$L_0$	$L_1$	$L_2$
$L_0$	0,0000 (0,0149)	0,3738 (0,0415)	0,0680 (0,0259)
$L_1$	0,1181 (0,0333)	0,0000 (0,0492)	0,0378 (0,0259)
$L_2$	0,0274 (0,0215)	0,3188 (0,0558)	0,0560 (0,0178)

**Higher Development with Complex**

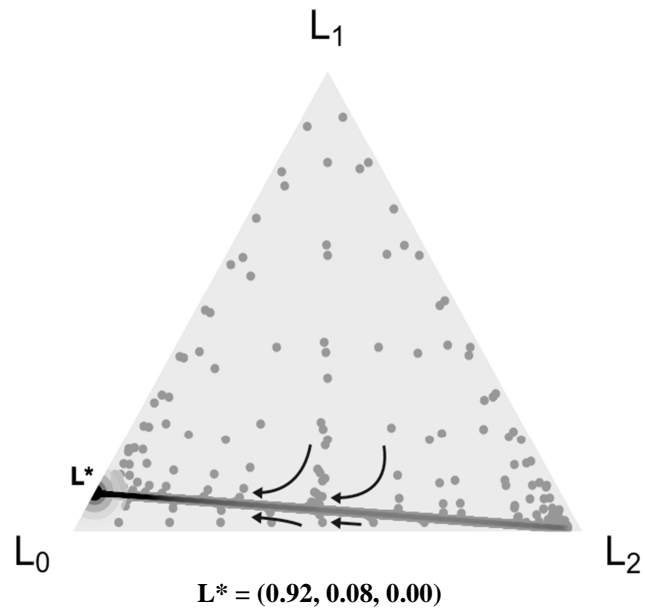
	$L_0$	$L_1$	$L_2$
$L_0$	0,0000 (0,0139)	0,4106 (0,0546)	0,0000 (0,0324)
$L_1$	0,0224 (0,0299)	0,1644 (0,0522)	0,0012 (0,0457)
$L_2$	0,0000 (0,0179)	0,4014 (0,0489)	0,0000 (0,0114)

*Dynamics*

**Higher Development with Simple**



**Higher Development with Complex**



### 5.3. Empirical Evidences and Limitations

Before discussing the empirical evidence discovered so far, I must point out the limitations of this project design, model and assumptions. Field research is important because variables of study are observed and collected “in the wild”, without the challenge of emulating reality in laboratories. On the other hand, they lose the power of control researchers have in the lab, making it harder to isolate other influences over the dependent variable. I believe a strong theoretical base supports my choices of variables and I rely on mixed methods to supply responses to some of the limitations of the project design. I expect the process tracing approach of the qualitative step will provide evidence to support not only the third hypothesis about barriers to learning, but also to strengthen the quantitative results found exploring the data, estimating fitness and analyzing the dynamics of learning.

Models are simplifications of reality that allow the study of relations between variables with the cost of several assumptions and approximations. I’d like to highlight two of these assumptions for the moment. The first is that choosing to consider population constant one loses the control over the possibility of “density dependence”, which is the influence of the size of the population over fitness. As I already argued, there is no theoretical motivation to assume such influence, since my definition of learning goes beyond individual minds, projects or groups. Moreover, this decision simplifies our model and the related analysis of the dynamics. The second assumption is that  $L_2$  is reflective because the problem of

compliance is solved for at least one quarter. I intend to study this assumption in depth in the qualitative step of this research, which will present examples of reflective and unreflective learning in case studies selected by combinations of agent types and project complexity.

In terms of the approximations, I may point out that when fitnesses are closer standard errors become relatively larger. Nevertheless, the dynamics of learning for each independent variable depends on all the relative fitnesses, not just on a pair, as explained in the Higher level of HDI. In that extreme example, even if the fitness of  $L_0$  were slightly higher than  $L_2$  in the  $L_1$  column, the dynamics would still confirm that adaptive efficiency is higher where the artifactual structure is better. Given these caveats and considerations, I proceed to a discussion on the method and empirical findings.

The evolutionary approach of this chapter was initially used to study lizards and is now adapted to learning types in the political economy of development. One can apply such method to a wide range of issues but I think it is highly suitable to the problem of development, especially when considering development an adaptive process. One advantage of analyzing the dynamics of learning while implementing public policies, for instance, is that policy makers can have a good idea of where and how the adopted solutions are going before the end of a project cycle, saving time and resources. Any public policy will have a set of requirements that can be coded as proxies of learning. The way individuals, groups, organizations or societies deal with such requirements will indicate how



they are learning and, moreover, the resulting dynamics produced by an evolutionary approach to the problem may anticipate whether a public policy is prone to success or failure. Ultimately, the approach I present in this research is a method to study adaptive efficiency by the measurement of path dependence to learning types in a wide range of situations, from public policies to corporate strategies, from small business to countries, from elections to social movements.

A zoom in the microgenesis of development in Brazil, in the examination of fundraising efforts for the production of social goods, unveils convincing evidences of a path dependent trap of unreflective learning. For the great majority of initial states of learning shares, the dynamics of adaptive development is a stream flowing away from reflective learning. It is in this sense that, as suggested by hypothesis (i), learning is a source of path dependence. Furthermore, it seems that when the artifactual structure of capabilities and institutions is unable to support adaptive efficiency, path dependence to unreflective learning is stronger, as suggested by the vicious cycle of the proposed analytical model.

When the question comes down to what we can do to unlock prosperity, attempting to turn vicious into virtuous cycles of development, agents organized in market relations and projects that are simpler to manage perform better than hierarchical power relations and complexity. Notice that one may find these results quite surprising, insofar common sense could create the expectation that big investments of complex projects and political influence of hierarchies would pressure the Bank's bureaucracy to approve requirements compliance. The

available data provides a striking support of the contrary, consistently showing hierarchies and complexity with more difficulties to increase  $L_2$  and decrease  $L_0$  than market relations and simple projects, especially when controlled for municipal development. The evidences from the analysis of the dynamics also support hypothesis (ii): hierarchical power relations and complexity increase path dependence to unreflective learning.

Two evidences confirm that one group is more path dependent to unreflective learning than the other. First, the dynamics converge to a steady state closer to  $L_0$  and, second, the flow running away from reflective learning is faster. This is the case of hierarchies compared to markets. The simple projects, in their turn, run to a steady state much closer to reflective learning than the 85% of  $L_0$  of those working in complexity. The system also converges faster when complexity is lower, but now running fast is good because it is towards the right side of the simplex. These results are similar when I control for higher development and the hypothesis still holds for lower development, but the advantages of markets and simplicity over hierarchies and complexity, respectively, are smaller. It seems that the vicious cycle predicted by the analytical model becomes a powerful obstacle, because moving away from the trap of unreflective learning is harder when the artifactual structure is weak. Moreover, in order to unlock reflective learning or, at least, reduce path dependence to unreflective learning, keeping it simple and market based should be considered as public policy recommendations for the production of social goods in Brazil.

## **6. Barriers to Learning in Vicious and Virtuous Cycles**

With the support of evolutionary game theory, the previous chapter presents evidence that: (i) learning is a source of path dependence in development, and (ii) hierarchical power relations and complexity increase path dependence to unreflective learning. In the analytical model suggested in section 4.1, hierarchies and complex projects were expected to create barriers to learning, undermining the possibilities of reflectiveness. These barriers constitute intervening variables between learning fitness and the independent variables of the model, namely power relations, complexity and the artifactual structure.

This analytical model is the product of the interdisciplinary study on theories of organizations, institutions and political economy of Chapter 3, which resulted in the empirical question about how learning types are affected by arbitrariness, dynamic complexity and transaction costs. While the independent variables came out from this empirical question, the intervening barriers to learning will unfold from the third hypothesis of this research, the subject of this chapter: (iii) vicious cycles of unreflective learning are reinforced by ambiguity, defensiveness and misperceptions of dynamic complexity.

Summarizing the theoretical argument, in the presence of high transaction costs, dynamic complexity and power arbitrariness, learning is blocked by ambiguous interpretations of the rules of the game, uncooperative defensive groups and individuals, as well as by misperceptions about the structures of the problems in

terms of time delays and feedback cycles. This statement describes the hypothesis as a process compounded by various mechanisms and intervening variables, rather than the typical relation of causality, requiring an appropriate research method. The next section presents the process tracing method, defines the variables and explains the case study approach used to explore such mechanisms. In the remainder of the chapter I analyze 8 cases, identifying a virtuous and a vicious cycle that confirm the process described by hypothesis (iii).

### **6.1. Process Tracing**

Researchers rely on cases in comparative methods not only when forced by the unavailability of data for larger N studies, but mainly in order to conduct in-depth analysis of causal relations. The use of mixed methods by scientists is not just an attempt to complement quantitative and qualitative techniques in large and small samples, it is also an approach to answer empirical questions in different levels of abstraction. Lieberman (2005), for example, suggests a “nested analysis” as an integrated approach that combines the advantages of statistics with the detailed investigation of one or more cases from the same sample. He points out that one can improve measurements and assumptions, as well as generate theoretical insights and explore new hypotheses iteratively moving between large and small N levels in the same inquiry. As Lieberman exemplifies, this approach is useful for the researcher who asks the general question of “what causes revolutions?” but is also interested in what was the cause of the French Revolution, in particular.

Mahoney (2003) makes a helpful distinction between cross-cases and within-cases in comparative methods. He explains that “within-case analysis” is a tool specifically designed to compensate for the limitations of cross-case methods, presenting three techniques suitable for different levels of abstraction. In “pattern matching” the analyst matches general hypotheses with specific cases, as in the example of the French Revolution. “Process tracing” is useful for identifying causal mechanisms that connect independent, intervening and dependent variables within cases, contributing to avoid mistaken conclusions motivated by spurious correlations found in the cross-cases level. Mahoney points out that tracing the mechanisms that compose the process defined by the causal relations in study, one increases the confidence either to confirm or reject the hypothesis testing performed in the level of higher theory. Finally, with “causal narrative” scholars disaggregate the general hypotheses in sequences of events within each case in lower levels of abstraction, in order to compare such historical narratives across cases.

This methodological debate takes place in the historical time scale and its tools are usually applied in the national level, however, as pointed out by Snyder (2001), the subnational comparative method also has the potential to increase methodological rigor. He argues, first, that the subnational perspective contributes to improve research designs increasing the number of observations and the possibilities of controlled comparisons. Second, this perspective eventually avoids the “whole nation bias”, i.e. the common mistake of taking the country by data collected in one city or region or by the average of very different areas. And third,

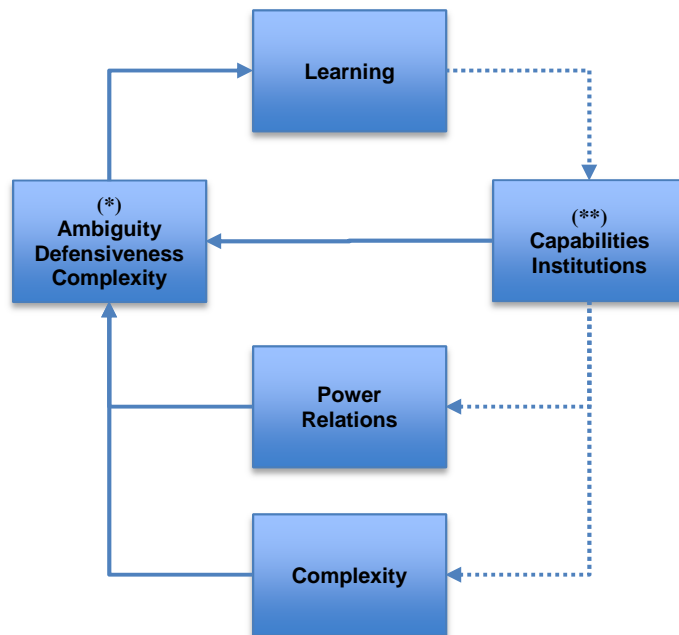
Snyder points out, disaggregating the whole in its parts makes it easier to observe the interconnections among variables, levels, regions and agents in the political and economic systems.

In fact, studying states, municipalities and companies I can control certain variables in greater extent than would be possible in the national level, such as macroeconomic stability and cultural aspects. As all the cases are submitted to the regulations of the same sector as well as are related to operations with the same developmental agency, contractual incentives and capabilities provided to the local agents are controlled to some extent as well. In this sense, the subnational choice improves my ability to trace the causal processes in operation, compared to higher levels of abstraction, while a qualitative approach of process tracing deepens the understanding of the causal chains that produce the cycles of adaptive development.

The goal of this stage of the research is to identify the mechanisms that connect learning types, barriers to learning and the independent variables of the model, which are the artifactual structure, power relations and complexity, in order to trace the process of adaptive development in two patterns: a vicious and a virtuous cycles. I will describe each pattern in terms of the distinct effects produced by the independent variables upon the barriers to learning. Applying the process tracing method these variables will be disaggregated in smaller components, as represented in Figure 6.1. The reader will notice that the analytical model

displayed here is the same originally presented in Figure 4.2, simply unveiling the components of barriers to learning and artifactual structure.

Figure 6.1 – Analytical Model with Detailed Barriers to Learning and Artifactual Structure



(\*) Barriers to learning: ambiguity, defensiveness and misperceptions about dynamic complexity.

(\*\*) Artifactual structure: capabilities and institutions.

Artifactual structures will be studied in the following cases by capabilities, such as technical knowledge and skills; and institutions, such as laws and organizational norms and practices. I will observe in the cases whether such components, combined with power relations and complexity, enhance or undermine the barriers to learning. The barriers to learning, in their turn, are misperceptions about feedback dynamics and time delays, ambiguous interpretations of rules and defensiveness of individuals and groups.

As a case selection criterion, the artifactual structure is still measured by the municipal HDI. Likewise, power relations are still defined by how much agents are susceptible to political arbitrariness, coded hierarchical for states, municipalities and state-owned companies (except publicly traded); or market based for publicly traded state-owned companies. Complexity is also still defined as simple or complex projects in terms of the size of the investment, with the R\$ 30 million threshold. The selection criteria for the cases are based on the 8 possible combinations of the categories of agent types, complexity and artifactual structure, with the same levels used before: hierarchy, complex, lower development (HCL); hierarchy, simple, lower development (HSL); market, complex, lower development (MCL); market, simple, lower development (MSL); hierarchy, complex, higher development (HCH); hierarchy, simple, higher development (HSH); market, complex, higher development (MCH); market, simple, higher development (MSH). In order to increase the chances to find examples of barriers to learning and reflectiveness, I also consider as criteria the size of the project and requirement status. Larger projects with more deliverables potentially have more room for problem solving situations and, once there is a pendent requirement, I can evaluate how the agent reacted to deal and learn with the mistakes. Hence, I select the case with the larger investment with at least one requirement error in each combination of categories. The result is a selection of 8 cases distributed in 6 states of Brazil, representing publicly traded companies, state owned companies and municipalities. The “simple” cases are investments close to the threshold of R\$ 30 million, while the “complex” investments go up to one billion. For reasons of bank secrecy the Brazilian Development Bank, from



now on “the Bank”, required that the names of companies and individuals related to the projects in the reports and interviews were not disclosed. Henceforth, I identify each case by the acronym of the combination of categories and use approximations for numbers that describe the project or the agent.

The first source of information for the case study was the same database of the quantitative analysis. Besides the requirements used to define learning types, the file had several fields for each record, including observations about the pendent requirements and the names of the managers of the projects. After selecting each case according to the defined criteria, I could observe the requirement errors and use the related observation as the starting point of my search through the reports. 78 assessment reports produced by the Bank were my second source, most of them with attached documents such as performance reports produced by the agents and correspondence such as letters and emails. I analyzed these documents searching for textual elements that would count as evidences to confirm my hypothesis. Finally, I had the opportunity to validate most of my findings with formal interviews, including a very interesting group discussion, and several informal chats with managers and analysts that worked in the cases.

## **6.2. Case Studies**

**HCL** (hierarchy, complex, lower) is a R\$ 60 million project of a sewage system with one treatment facility and a sanitary sewer network with capacity to attend 15,000 households of a municipality with one of the lowest development levels of

the original sample. The agent is a state owned company, not publicly traded, financially healthy, with a very good relationship with the Bank and an excellent credit rating.

The technical project is well detailed in the reports and was approved with a schedule of 48 months, including a set up period for complying with the requirements of the Bank that conditioned the disbursement of the tranches. The engineering project was delivered very soon, but the other three requirements remained pendent from the signature of the contract in 2014 to the last assessment report analyzed, from 2016. Looking for the reasons why these errors were so persistent, I found an anterior problem that unfolded very closely to the prediction of the hypothesis in examination.

Naturally, every lending contract has guarantees that protect the Bank from the eventual default of the counterparty. The rules of the Bank about how these guarantees are provided are quite clear, but the agent must know and be able to manage the laws and the internal rules of all the funding sources of its investment programs. It turns out HCL's guarantees were given to another bank as well, and the Bank had to fine the company and couldn't make any disbursement for the project.

The first trial of HCL to solve the problem was in the technical level, with an attempt to cancel certain obligations of the contract with the other bank, which failed because these obligations were irrevocable by law. In sequence, the

documents report an escalation to the political level, with meetings of the top executives of all interested organizations. The conclusion of the last report has an interesting textual passage: while one president and one director communicated the “desire to start the construction” in the short term, technical employees of the same organizations “considered such scenario unlikely” to occur.

The guarantees issue surprised HCL’s team because they had an ambiguous interpretation of the related financial norms. This could be a problem with the institutions, which were unable to reduce transaction costs, but it seems more an issue of insufficient capabilities related to financial regulation. As stated by a senior manager, project teams usually present adequate guarantees and easily renegotiate its replacement whenever necessary. Anyhow, this situation is an example of how the weak artifactual structure reinforces ambiguities operating as barriers to learning. When HCL adaptively reorganized to solve the problem, the ambiguous interpretation about the irrevocable obligations blocked a more reflective solution, keeping the project unfunded and the city without the public good.

In the second trial of adaptive reorganization, presidents and directors met and agreed to start the project, a desire that was dissonant of the technical perception of reality. The reports say the project team sent all the required information about the guarantees, but there are no examples of actions towards the advance of the project or at least of solutions about the bidding process, environmental licensing or land entitlement. The prudent diagnosis about the project’s schedule of the

technical teams was a sign of defensive behavior, but the evidence was the complete inaction on regard of all the other requirements and possible fronts of the project. Defensiveness blocked possible reflective solutions for the project, but the identification of the source of power arbitrariness that produced such reaction is fuzzy. HCL project team suffered the exercise of hierarchical authority not only from their top executives, but also from the state and the banks. Without such a defensive attitude, project teams of this case would be able to cooperate in the search of a technical solution, either simply replacing guarantees or reflecting upon and improving the internal and external norms that were the source of ambiguity.

**HSL** (hierarchy, simple, lower) is a R\$ 30 million project for the expansion of a water supply system, including the construction of reservoirs, pumping stations, main water pipes and a distribution network. The agent is a state owned company, not publicly traded, with a good credit rating. Since the beginning of the construction, the project developed right on the timeframe with satisfactory results in all matters, as stated in the assessment reports. However, it took 2 years between the signature of the contract and the first day of construction. The examination of the motives that resulted in this delay unveils an interesting mechanism of misperception of dynamic complexity in the access to public funding.

All the cases in this research, including HSL, were part of programs of the federal government coordinated by the Ministry of Cities that included credit operations

for water & sanitation projects. In order to explain the underlying dynamics that weakens learning in such situations, I will go back a few years in time. In the 1990s and 2000s, as part of a set of austerity policies designed to deal with the debt crisis, the Brazilian government created regulations to limit the public debt. In 2001, the Brazilian Central Bank issued the resolution n° 2.827 to control the public sector's credit, including states, municipalities and state owned companies, which became submitted to federal government authorization to contract new credit operations. The inception of the Ministry of Cities in 2003 changed the process of credit concession, from a centralized line of projects to a group of distinct sectorial lines, coordinating the credit to projects of water & sanitation by normative instructions.

The main criticisms to the new procedure were that such legal instruments were issued somewhat randomly, with very short schedules for proposals, with the addition of new rules each time, embodying a high level of uncertainty to the process. HSL had to present a proposal in 30 days and, after a positive response, less than 2 months to present the engineering project. The instruction also had a deadline for contracting, but it was repeatedly postponed. The bottom line was that very few agents had detailed engineering projects for the application and the program ended up with a portfolio of very basic projects. Most of these projects had to go through “a long period of preliminary actions about the project design, environmental licensing, land entitlement and bidding processes”, as stated in one of HSL's assessment reports.

The underlying problem of the process was a dynamic complexity similar to the logistics of stocks in the retail business. Project managers confirmed that the demand for projects was unpredictable, compressed in short periods of time, requiring the management of a stock of projects ready to be presented to the Ministry. Since the rules could also change, the cost of keeping a stock of projects was high, because the company would not be able to optimize the fit between its portfolio of engineering projects and the criteria of selection of each new normative instruction. Such dynamic complexity produced misperceptions about timing and delays, blocking the possibilities of reflective learning and affecting the quality and the costs of projects such as HSL.

**MCL** (market, complex, lower) applied for funding in the same process described above, but with a very different outcome: during the 2 years HSL was setting up to start the project, MCL had 80% done. The project is an R\$ 100 million sewage system expansion, including the increase of the capacity of one treatment facility and the construction of a new one, as well as a sanitary sewer network that benefits 50,000 households. The agent is a publicly traded company, with an excellent credit rating and a diversified relationship with the Bank, including loans and debentures.

Even though MCL had more success than HSL, the trajectory of the project was not smooth. The assessment reports describe adaptive reorganizations constantly solving problems of project adjustments that required the coordination of analysts and managers in the Bank, the company and the Ministry. Even in the face of high

transaction costs of submitting modifications in the project to the bureaucratic process, MCL was able to anticipate solutions and keep the schedule of the project on track.

There are two examples of reflective learning in this case that I would like to highlight. The first was a contract amendment. In order to present the proposal in the short timeframe of the normative instruction, MCL left pending a few environmental requirements. A typical solution of the Bank when contracts need to be signed before a deadline is turning certain pre-contracting conditions into conditions required before the first disbursement. In MCL's case, the licensing process was taking the sewage system as a whole and the analysts foresaw a delay while waiting for the issuance of a single license for the whole project by the environmental authority. Analysts from the Bank and the company realized that disaggregating the object of licensing in parts would simplify the process and allow an earlier start for that deliverables that could be authorized before the others. The cost of working in a contract amendment, reflectively changing the project and the formal institution that governed the relationship between the Bank and the agent, was lower than the cost of waiting for a single environmental document. This adaptive reorganization was fundamental to make the project start on time.

In a group discussion I organized as part of the research, a manager who worked in the project reported a second example of reflective learning that I found surprising. He pointed out that, after learning with the stop-and-go process to

access funding, the company developed the costly database of projects mentioned in the previous case. At least for MCL, the cost of having such stock of projects was lower than the transaction costs of dealing with the Ministry of Cities after all.

**MSL** (market, simple, lower) is a small project of R\$ 20 million for the construction of four compact sewage treatment facilities that would benefit 50,000 people. The agent is a publicly traded company, with a good credit rating and a diversified relationship with the Bank, including loans and debentures.

MSL also went through the Ministry of Cities' process, as part of a big application for projects in several locations, exposing managers and analysts to the same challenges explained in the other cases. MSL's reports show the delay in the bidding and environmental processes, resulting in the reduction of the scope for only two treatment facilities, instead of four. However, while the problems in the other cases seem to be related to barriers to learning, in MSL the delays and changes of the project were mainly the result of technical solutions in benefit of the public good.

The construction of two of the four treatment facilities couldn't start as planned because they had difficulties complying with the environmental requirements. Analysts figured out that insisting in the quest for compliance in these problematic items would take longer than changing the project itself. Engineers changed the project design connecting the neighborhoods where they would be implemented to



the main sewer collection system and, consequently, to the central treatment plant, delivering to the population of the city a solution that was better than the one initially offered. MSL case had a significant change that resulted in revisions of the bidding process and delays, but the reorganization described in the reports exemplifies a remarkable reflection upon the technical aspects of the engineering project that delivered a creative response to the environmental licensing problem.

**HCH's** (hierarchy, complex, higher) agent is a municipality with 400,000 inhabitants, located in the South of Brazil, with a very good fiscal situation. The project of R\$ 100 million is a water supply system, including facilities of water extraction and treatment, reservoirs, pumping stations and main water pipes. The initial schedule had 30 months and the goal was preparing the city for a predicted fast population growth.

Likewise other cases, HCH had to make adjustments and run after requirement's compliance, experiencing delays in bidding processes, environmental licensing and land expropriation, ending up with only 40% of the project delivered after 30 months. Moreover, in this case the consequences of the barriers to learning inherent to the funding process were more costly. Trying to follow the unpredictable schedule and moving deadlines defined by the Ministry of Cities, HCH's proposal presented a detailed project but with an outdated budget. The Bank noticed a budget increase of 50% that had to be funded by the municipality.

Budget shortages can have many causes related to resources availability, scope changes or deadline updates, most of them well known to experienced project analysts. Capability improvements, such as in cost analysis and managerial skills, as well as adequate institutions, such as standard references for estimating costs, may help prevent certain budget problems. In any case, in order to achieve the goals of the project, the Bank requires that the agent uses its own resources or raises funding until completion.

Rather than a stable horizon for infrastructure investments, the Ministry's process of credit concession created a dynamic complexity in which budget spreadsheets became only one more appendix in a bunch of documents required by the bureaucratic procedures. HCH couldn't follow the rules and deadlines of the Ministry without losing budget accuracy, ending up not grasping the consequences of bad timing and delays in the future execution of the project. Like HSL, HCH couldn't overcome the obstacle of dynamic complexity and misperceptions about timing and delays blocked the possibilities of reflective learning, resulting in a budget shortage.

**MCH** (market, complex, higher) is an R\$ 1 billion program of investments with funding from the Bank, from an international development bank and of their own. The projects take place in nine municipalities, with a 1,000 km sewer network, seven treatment facilities, 100 pumping stations and other items. The agent is a publicly traded company, with a good credit rating, access to international capital

markets and a diversified relationship with the Bank, including loans and debentures.

Given the size of the investment, technical complexity and the bureaucracy MCH went through, the project was remarkably successful. Analysts pointed out upfront the risks of delay, budget shortage and regulatory uncertainties about the agreements between the agent and the municipalities in which facilities would be constructed. Even so, except for one municipality, the projects finished right on the deadline of 4 years.

One of the critical factors of this project was the number of environmental processes that would have to be managed, so the agent worked to obtain such documents before approving the project in the Bank. Since one municipality didn't make it, the analysts segregated a sub credit in the contract and managed a realistic longer schedule for that project. MCH mitigated the other risks in the same fashion, reflectively anticipating solutions in all fronts.

Senior executives reported that MCH's company was able to contribute for the improvement of the environmental authority within the state bureaucracy. With big investment programs the company motivated institutional improvements in the environmental authority, which started to fast track the licensing process of projects with low or positive environmental impacts, such as sewage facilities. This is the learning wave in motion: from the desk of the analyst a reflective solution propagates throughout the minds and documents of various groups

involved with the project, reaching a meeting room in the environmental department where managers discuss and adaptively reorganize the procedures that simplify authorizations for sewage projects.

In another example, MCH effectively anticipated the negotiation of financial covenants of the loan contract. Such covenants are agreements between the Bank and the borrower on certain indicators that inform the financial health of the latter. In a situation of financial deterioration, the covenant clauses allow the interruption of disbursements and protect the Bank from future losses. The company was adjusting internal rules to the International Financial Reporting Standards (IFRS), affecting accounting calculations and consequently increasing the uncertainty about the accomplishment of the covenant's goals. Hence, the project teams anticipated the negotiation of a waiver, changing the agreement and prevented a disbursement interruption when the debt/equity ratio got slightly higher than predicted in the contract. Assessment reports explain that the changes in the indicators after the IFRS were marginal, but the result could have been costly if no reflective move had reduced ambiguities previously.

**HSH** (hierarchy, simple, higher) is a R\$ 20 million water supply project with three items: improvement of a treatment facility, one reservoir and a main water pipeline. The agent is a state owned company, not publicly traded, with a good credit rating. The contract is from 2008 and, even though the initial deadline was in 3 years, in 2010 the project had only a 30% of execution.

In the assessment reports, project analysts acknowledge the environmental compliance and the agreement with the municipality where the facilities were located. In fact, licenses were updated in each of the eight reports I analyzed and there was no conflict with the city. The reservoir and treatment facility fronts accelerated after a while, catching up the schedule, and there were no critical bidding or engineering issues reported. The cause of the delay was exclusively a hard negotiation in the land expropriation process for the water pipeline. Besides an area that belongs to the Army and a railroad, there were 22 private properties throughout the trajectory of the pipeline. The project took twice the time initially planned, but the public good was delivered. One can speculate about whether project managers and engineers could have anticipated a solution to the problem, but I didn't find examples of barriers to learning as evident as in the previous cases. It seems in this case the problem was simply time consuming, and the project management was business as usual.

The agent of the last case is a publicly traded company, with a good credit rating, access to international capital markets and a diversified relationship with the Bank, including loans and debentures. **MSH** is a project of R\$ 25 million in a program of R\$ 250 million with a general goal of improving the water and sanitation systems in 32 municipalities.

The conception of the program was itself a reflexive reaction to the process of the Ministry of Cities. Instead of trying to figure out the dynamic complexities and ambiguities of the process upfront, MSH put their projects under a program

umbrella that was planned to have flexibility in terms of schedule and budget. The initial proposal had estimates that took into account the possible delays and extra costs of bidding, environmental licensing, project adjustments and so on. Hence, MSH was a very long project, but instead of the typical problems seen in the other cases, the delay was the result of a budget spare that made possible the expansion of the scope of the project with new investments.

### 6.3. Ambiguity, Dynamic Complexity and Defensiveness

Looking at each case with the empirical question in mind, I found examples of barriers to learning and reflective solutions in various problematic situations. The actions and reactions of each project team in the face of difficulties inherent to the process of funding were different, but very interesting patterns emerged from the comparative analysis.

Figure 6.2 – Barriers to Learning Matrix

Reflective Learning	Yes		<i>MCL</i>	<i>MSH</i>	
	No	<i>HCL</i>	<i>HCH</i>	<i>MSL</i>	<i>MCH</i>
		<i>HSL</i>		<i>HSH</i>	
		Yes	Barriers to Learning		No

Figure 6.2 summarizes the findings displaying 4 cases with reflective learning and no barriers; 3 cases with barriers to learning and no reflectiveness; and 1 case in which I didn't find examples of neither barriers or reflectiveness. Notice that when barriers were present, no reflective learning was found. This result confirms the idea of the hypothesis that barriers to learning, i.e. ambiguity, defensiveness and dynamic complexity, block reflectiveness, i.e. a "double-loop" learning type in which not only the direct causes but also the underlying structure of the problem comes into question.

The cross-cases analysis supports the results of the logit model of Chapter 4 as well as the conclusions on learning fitness dynamics of Chapter 5. All the cases with reflective learning and no barriers, in the upper right of the matrix, are market-based relations. The cases show how publicly traded companies strategically anticipate solutions and adapt faster to deal with changing circumstances than the agents tied in hierarchical relations. After knowing the details of the project, HSL being in the opposite quadrant is not surprising. While with a small investment, the source of complexity HSL was not able to reduce was the funding process. In this sense, it supports the previous conclusions as well.

Applying the within-cases method I could trace the mechanisms through which vicious cycles of unreflective learning are reinforced by ambiguity, defensiveness and misperceptions of dynamic complexity, as stated in hypothesis (iii). I also discussed each of the intervening variables of the barriers to learning and provided

examples of reflective learning that support the assumption of reflectiveness of  $L_2$  explained in Chapter 5.

The bottom left of the matrix portrays a group of cases that couldn't overcome the barriers to learning. In HCL, a lack of knowledge about the rules that regulate credit operations reinforced ambiguities when a problem with guarantees came up. In addition, arbitrariness of political escalation produced a defensive reaction on the project team, instead of a solution. With capabilities and institutions unable to reduce transaction costs and arbitrariness, ambiguity and defensiveness blocked the reflective solutions that would have solved the problem and would possibly have improved such capabilities and institutions back. Moreover, the project had no disbursement, literally affecting the development prospects of a very poor location.

All the cases suffered with high transaction costs, arbitrariness and dynamic complexity of the process of accessing credit coordinated by the Ministry of Cities. Timing of issuance of normative instructions and unpredictable changes in the criteria of project selection turned the funding process into a difficult challenge. Some projects adaptively reorganized themselves to accomplish their goals, but for HSL and HCH the costs were high. HSL took 2 years adjusting the project and setting up requirements before starting the construction, while HCH saw an increase of 50% of the initially planned budget.



Except for HSH, that was business as usual, the projects that managed the funding process successfully applied stronger capabilities and improved institutions, undermining the barriers to learning in a virtuous cycle of reflectiveness. MCL actions were strategic, developing a stock of projects ready to novel credit programs; and making an amendment to the contract, separating the objects of environmental licensing in order to start the project, avoiding the wait for a single license. MSL also made a clever move to avoid the arbitrariness of the environmental authority, simply changing the project to a better technical solution instead of insisting in the requirements that were taking too long. MCH started a negotiation about the contractual covenants long before the impact of IFRS, and was influential to improve the environmental process of the state authority. Finally, MSH strategy was the definitive solution for the dynamic complexity of the funding process. The proposal was a program of investments to be detailed in projects during the implementation, with flexibility of budget and schedule.

While the group with barriers to learning is locked in a vicious cycle of unreflective learning, in the group with no barriers analysts and managers reflectively create solutions that change the story of the project, the organizations around them, the people served by the public good and themselves. In this sense, two patterns explain adaptive development: a vicious and a virtuous cycle.

In the vicious cycle capabilities are weak and non strategic, institutions are complicated and hierarchical, and agents are reactive. These characteristics reinforce ambiguity, misperceptions of dynamic complexity and defensiveness,

with less cooperation, reduced flow of information and few risks taken in order to change the *status quo*. The barriers block reflective learning and the possibilities of capability building or institutional improvement, resulting many times in delays, higher costs and privation of public goods. This cycle viciously lock societies in lower levels of development.

On the other hand, the virtuous cycle reflectively produces capabilities and institutions, reducing the barriers to learning. I found evidence of reflective local design and change, innovative and strategic capabilities able to anticipate solutions with creativity, as well as continuous improvement of institutions, such as in contract amendments and environmental licensing processes. With lower barriers to learning, organizations are more cooperative and have a clearer picture of the structure of the problem they face as well as of the means they have to solve it, producing solutions that question not only the task, but also the underlying norms and beliefs that govern their actions. This cycle is virtuous because reflective learning reinforces capabilities and institutions; these elements reduce barriers to learning; and reflective learning is reinforced back.

## **7. Conclusion**

Development is a learning wave. There is nothing metaphorical in the idea of the microgenesis of development as a wave of adaptive learning. More than an appealing image of development propagating in every direction and through time, the dynamics of adaptive learning is a real process with material and non-material consequences. Depending on the type of learning that prevails, artifactual structures evolve and barriers to learning strengthen or weaken. When they grow, strong barriers lock individuals, organizations and societies in vicious cycles of unreflective learning. This research is an attempt to understand and unlock such patterns towards the path of prosperity.

The main argument is that when capabilities and institutions are unable to reduce transaction costs, dynamic complexity and power arbitrariness, reflective learning is blocked by ambiguous interpretations of the rules of the game, uncooperative defensive groups and individuals, as well as by misperceptions about the structures of the problems in terms of time delays and feedback dynamics. Without the ability to unlock reflective learning, capabilities and institutions remain unable to undermine the barriers to learning, closing the vicious cycle of underdevelopment.

This argument was the product of a theoretical discussion on the role of adaptive learning in the subfield of political economy of development. It started with the proposition that the approaches of political economy based on interests, culture or

institutions, as typified by Hall (1997), are limited to explanations about how political and economic choices are framed. I propose a different way to posit the question: rather than asking to which direction decisions are guided by incentives or constraints, we should ask whether political and economic agents are learning from the feedback signs of experience over time. Turning this analysis to the influential concept of credible commitments proposed by North and Weingast (1989), I argued that incentives explain how we make choices but not how we improve adaptive efficiency. More than just providing incentives and constraints, institutions allow agents to adapt learning from success or failure in the polity and marketplace. Reviewing Weingast (1995), I claimed that the power decentralization offered by certain federal arrangements can encourage institutional and policy experimentation. In this sense, we should focus more on policy improvement by learning than just on policy design. Looking at his narrative about the relation between formal and informal institutions after the Glorious Revolution, I attempted to make clear an implicit process of learning in politics, in which continuous human interaction builds practices, and continuous practicing is consolidated into beliefs.

In sequence, studying theories of institutional change, I made the argument that when scholars borrowed from the literature on increasing returns organized by Arthur (1994) the concept of path dependence, they emphasized the aspects related to costs and coordination (North, 1990), and added the perspective of power (Pierson, 2004), giving much less attention to the process of learning. Besides, we take “learning effects” as incentives or constraints that frame

behavior and know little about the learning processes that build knowledge, other capabilities and institutions. My suggestion is that, more than discussing static stocks and their influence upon individual and organizational choices, we must study the dynamic flows of processes of learning in the face of continuous change that feeds back such stocks, a process of adaptation that can either lock us in less developed patterns or unlock development.

Closing my inquiry on the unexplored role of adaptive learning, I pointed out that the literature about institutions and political economy should take the next step towards a theory that understands development as complex phenomena. We've been focusing too much in how incentives and constraints drive us to specific goals, but little attention has been given to change itself. Rather than just engaging on designing institutions, policies and projects, we should study the learning mechanisms that allow continuous improvement in these matters. I think the institutional explanation for the political economy of development must be complemented by a dynamic and systemic approach, in which institutions leverage agency when they operate as learning mechanisms, empowering individuals and organizations to harvest the best outcomes from threats and opportunities imposed by the circumstances.

In order to explore the learning processes hidden in the feedback dynamics I pointed out in the literature, I suggested an evolutionary approach that takes development by its composite systemic processes rather than by explanatory variables in unidirectional causality. Understanding development as a process of

fortune taming by decentralized adaptive learning, I built on Nelson and Winter (1982) to argue that society should be taken as a learning system in which capabilities and institutions co-evolve. In this context, I looked at Distributed Cognition (Hutchins, 1995) as a perspective to complex systems that allows a drill down to the microgenesis of development in the learning process of adaptive reorganization, arguing that capabilities and institutions are products of reflective and unreflective learning types that combine in evolutionary processes. With the support of an interdisciplinary literature, I concluded the theoretical inquiry discussing how dynamic complexity, transaction costs and power relations produce ambiguities, defensiveness and misperceptions of feedbacks and timing that influence learning processes in path dependent cycles of development.

Based on this theoretical discussion, I defined learning as adaptive reorganization in the process of trials and errors; and development as an evolutionary process in which more or less reflective learning types gain or lose shares over time. I built an analytical model of adaptive development in which the artifactual structure of capabilities and institutions affects ambiguity, defensiveness and the perception of dynamic complexity. When the artifactual structure strengthens these barriers to learning, development is a vicious cycle of unreflective learning. On the other hand, when barriers to learning are weakened, development is a virtuous cycle of reflectiveness.

The artifactual structure affects barriers to learning directly reducing transaction costs, as stated by mainstream theories, but also by the way they organize power

relations and reduce dynamic complexity. Hence, the empirical model has artifactual structure, power relations and complexity as independent variables; learning fitness, which is the ability of a learning type to gain or lose shares, as the dependent variable; and ambiguity, defensiveness and dynamic complexity, the barriers to learning, as intervening variables.

The empirical questions represented in the analytical model unfold in three hypotheses: (i) learning is a source of path dependence in the process of development; (ii) hierarchical power relations and complexity increase path dependence to unreflective learning; and (iii) vicious cycles of unreflective learning are reinforced by ambiguity, defensiveness and misperceptions of dynamic complexity. In order to examine such hypotheses, the research project had two stages: a large N study of learning fitness and a process tracing case study on the barriers to learning.

These stages were necessary not only for the complementary advantages of the quantitative and qualitative approaches, but because the hypotheses asked empirical questions that required different methods. In the first stage I started exploring the data estimating the odds of the independent variables to produce reflective learning. I found that the odds of market agents to learn reflectively is 88% higher than hierarchies; while the odds of a project to produce reflective learning is 56% lower for a tenfold increase in the size of the investment.

These results supported the choices of variables, but the hypotheses required a method to analyze the dynamics of shares of learning types changing through time. Studying such dynamics with a model of Evolutionary Game Theory, I found the underlying patterns of path dependence to learning types I was looking for. For the great majority of initial states of learning shares, the dynamics of adaptive development was a system converging to unreflective learning. In this sense, learning is a source of path dependence in the process of development, as stated by hypothesis (i). Furthermore, when the artifactual structure of capabilities and institutions was unable to support adaptive efficiency, path dependence to unreflective learning was stronger, as suggested by the vicious cycle of the proposed analytical model and confirmed with the control for municipal development.

The missing links capable to reverse this cycle were the barriers to learning produced by power relations and dynamic complexity, a set of variables studied with agent types and complexity levels as explanatory variables of learning fitness in the evolutionary game model. While common sense would expect that big projects and political influence of hierarchies would pressure the Bank's bureaucracy to approve requirements, the results provided a striking support of the contrary, consistently showing market-based relations and simple projects with less difficulties to let reflectiveness grow and decrease unreflective learning than hierarchies and complex projects, especially when controlled for municipal development. The evidences from the analysis of the dynamics also support



hypothesis (ii): hierarchical power relations and complexity increase path dependence to unreflective learning.

In hypothesis (iii), vicious cycles of unreflective learning are reinforced by ambiguity, defensiveness and misperceptions of dynamic complexity. As stated, it required a zoom in a set of cases in which I could trace the mechanisms that connected the intervening variables of barriers to learning with the other variables of the model. Applying the process tracing method with case studies, I could identify a group of cases with evidences of barriers to learning locked in a vicious cycle of unreflective learning, as well as a group with no barriers in which analysts and managers reflectively created solutions that changed the project, the organizations around them and the society served by the public goods. Hence, two patterns explain adaptive development: a vicious and a virtuous cycle.

In the vicious cycle capabilities are weak and non-strategic, institutions are complicated and hierarchical, and agents are reactive. These characteristics reinforce ambiguity, misperceptions of dynamic complexity and defensiveness. Such barriers block reflective learning and the possibilities of capability building or institutional improvement, viciously locking societies in lower levels of development. On the other hand, the virtuous cycle reflectively produces capabilities and institutions, reducing the barriers to learning. Capabilities are innovative and strategic, while institutions are continuously improving. With lower barriers to learning, individuals and organizations cooperate, exchange

ideas and produce solutions that question not only the task, but also the underlying norms and beliefs that govern their actions.

The object of this research was a group of projects trying to access governmental funding for investments in water & sanitation. The cases made clear that the funding process has transaction costs, dynamic complexity and power relations that nourish barriers to learning. In this sense, any actions targeting the reduction of ambiguities in laws, normative instructions and organizational norms; of uncertainties in terms of timing and delays that affect costs of project design and management; as well as of political arbitrariness in the coordination of the process, would be very important to improve investments in the sector. As a result of this research, in order to unlock reflective learning or, at least, reduce path dependence to unreflective learning, keeping it simple and market based should be considered as public policy recommendations for the production of social goods in Brazil.

Despite the caveats and limitations pointed out in the end of each empirical chapter, the Evolutionary Game Theory and Process Tracing methods were very important, suitable and even required for the challenging dynamics and intervening variables of the analytical model. Nonetheless, there are other methods capable to deal with such complex dynamics, such as Agent Based and System Dynamics modeling. Further research with the application of these and other methods could potentially reinforce and expand the findings generated here.

This work was not designed as a sectorial or organizational diagnosis, but the method is suitable for unfolding to a wide range of policy making and organizational management applications. Banks can improve credit analysis using their own requirements, including the honor of financial obligations, to measure the learning ability of their clients, simulating and anticipating the performance of assets, portfolios and projects. Developmental agencies can study the learning dynamics of different sectors, regions, agent types and a variety of possible treatments, in order to identify and act upon the reasons why some investments have unsatisfactory results, particularly in cases in which the old fashioned solutions based on incentives and constraints have been failing. Organizations may also improve internal capabilities and institutions looking at learning dynamics of business units and departments, coding performance according to strategic indicators, including standard financial measurements, as learning types. In this sense, one can estimate learning fitness in order to identify units that have been falling behind and simulate dynamics before committing resources. Moreover, with the qualitative approach one can identify barriers to learning and propose reflective solutions to improve the performance of such business units and departments. In brief, starting with a good definition of requirements or indicators that represent the ability to learn, this method is useful both for further research and for improving the management of projects, programs and business units of various kinds.

Finally, I would like to highlight that one of the main contributions of this work was the effort to push the political economy of development from a theory of

choice to a theory of change. This shift opens new possibilities for debates, a new research agenda with learning types in its core and with development taken as a process of fortune taming and continuous improvement of adaptive efficiency. Understanding the dynamics of adaptive development we will learn how to learn and produce reflective solutions that will set us free from path dependent patterns of underdevelopment that have been puzzling everyone for so long.

We must keep adding efforts for pursuing new perspectives to deal with the continuously changing circumstances and new challenges, since not even the old problems remain the same after a while. The findings I present here wouldn't be possible without a novel perspective that took into account a learning wave moving in Hutchins' distributed cognition as a source of path dependence, defining development as Hayek's evolutionary process of trials, errors and adaptation. While the arguments and findings presented in this research are quite interdisciplinary, I believe my contribution takes part in the efforts of development studies based on an ancient idea of social evolution that, according to Hayek, was borrowed from the social sciences by biologists and not the other way around<sup>71</sup>.

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<sup>71</sup> Hayek (1960), p. 53.

## 8. Appendix

### 8.1. Logit Model

The following is a transcript of the R Studio console in which I use the *pglm* package, a panel generalized linear model that includes the logit link in the binomial family. I run the model using the Broyden–Fletcher–Goldfarb–Shanno (BFGS) algorithm, a quasi-Newton method of numerical optimization, with results that support my research design, as explained in Chapter 4.

```
> Logit <- pglm (L2 ~ Market + LogSize + HDI, Data, method="BFGS",
family=binomial(logit))
> summary (Logit)
```

```
-----
Maximum Likelihood estimation
BFGS maximization, 61 iterations
Return code 0: successful convergence
Log-Likelihood: -3920.383
5 free parameters
Estimates:
              Estimate Std. error t value Pr(> t)
(Intercept)  5.92755    0.73339   8.082 6.35e-16 ***
Market       0.63380    0.07989   7.934 2.13e-15 ***
LogSize     -0.81580    0.06784 -12.025 < 2e-16 ***
HDI         -0.17733    0.84108  -0.211  0.833
sigma       3.81076    0.11389  33.460 < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
-----
```

```
> exp(coef(Logit))
(Intercept)      Market      LogSize      HDI      sigma
375.2345004  1.8847589  0.4422858  0.8375065  45.1847666
```

```

> confint(Logit)
                2.5 %    97.5 %
(Intercept)  4.4901257  7.3649766
Market       0.4772257  0.7903741
LogSize     -0.9487635 -0.6828344
HDI         -1.8258145  1.4711620
sigma       3.5875422  4.0339778

```

## 8.2. Estimating Fitness

The model used to estimate fitness for learning types was first developed to study lizards by Friedman, Paranjpe, Magnani and Sinervo (2016) and made available as a Matlab code by Magnani, Friedman and Sinervo (2015). Besides estimating fitness, these authors use temperature and population density as covariates that affect the rock-paper-scissors dynamics of their evolutionary game. Without covariates, I adapt their basic model without the addition of temperature and population for my research design. This section explains the model and presents the Matlab code used in this work.

My original data set is a panel of projects by dates, coded by learning types, summing up to 9,525 lines. With  $n = \sum_i n_i$  projects for each date  $t$  one can easily calculate the shares of learning types as the relative frequencies  $L_i(t) = \frac{n_i(t)}{n(t)}$ ,  $i = 0, 1, 2$ , where  $\sum_i L_i(t) = 1$ . With 58 months, I get 3 x 58 vectors of shares for the whole data, which is the total portfolio of projects, as well as for each category of variables: agent types, complexity and municipal development. The goal of the

model is the estimation of 15 fitness matrices that are most likely to produce the observed data of the Total Portfolio as well as of each variable and combination of variables studied: Higher HDI, Lower HDI, Market, Hierarchy, Simple, Complex, Higher with Market, Higher with Hierarchy, Higher with Simple, Higher with Complex, Lower with Market, Lower with Hierarchy, Lower with Simple and Lower with Complex.

As explained in Chapter 5, the discrete time replicator equation is the deterministic part of the model,

$$Z_i(t) = \frac{W_i(t-1)}{\bar{W}(t-1)} L_i(t-1),$$

while the Dirichlet distribution specifies the stochastic part:  $L_i(t) \sim \text{Dir}(NZ_i(t))$ .

Hence,  $L_i(t)$  is a random variable with mean  $Z_i(t)$  and variance  $\frac{Z_i(t)[1-Z_i(t)]}{N+1}$  on the simplex  $\mathbf{S} = \{(L_0, L_1, L_2) \in \mathbb{R}^3: L_i \geq 0, \sum_i L_i = 1\}$ . Inversely related to the variance,  $N > -1$  is the precision parameter that represents densities concentrated closer to the mean when larger, and indicates more dispersion when smaller. The Dirichlet distribution is “tailor-made” for our problem because it is a conjugate prior for the multinomial distribution of projects with density zero outside the simplex. The general probability density  $\text{Dir}(\alpha)$  of  $x = (x_1, \dots, x_k)$ , parameterized by  $\alpha = (\alpha_1, \dots, \alpha_k)$ , when  $x \in \mathbf{S}_k$  is

$$f(x_1, \dots, x_k | \alpha_1, \dots, \alpha_k) = \frac{\Gamma(\sum_{i=1}^k \alpha_i)}{\prod_{i=1}^k \Gamma(\alpha_i)} \prod_{i=1}^k x_i^{\alpha_i - 1},$$

where the expression before the product  $\Pi$  is just a normalizing constant that ensures the function is a probability, i.e. makes it sum up to 1, using the gamma function  $\Gamma(z) \equiv \int_0^\infty y^{z-1} e^{-y} dy$ .

Therefore, for any count vector  $(Nz_0, Nz_1, Nz_2)$  from the data set,  $Dir(NZ_i(t))$  gives the probability that the underlying vector  $p = (p_0, p_1, p_2)$  is  $x \in \mathcal{S}$ , with probability density function for  $x = (x_0, x_1, x_2)$ :

$$f(x_0, x_1, x_2 | N, z_0, z_1, z_2) = \frac{\Gamma(N)}{\prod_{i=0}^2 \Gamma(NZ_i(t))} \prod_{i=0}^2 x_i^{NZ_i(t)-1} I_{x \in \mathcal{S}},$$

where  $I$  is the indicator function which is zero outside the simplex and 1 on the simplex. The intuition here is that, since each vector  $x$  is itself a probability distribution, the Dirichlet can be thought as a probability distribution over the multinomial distribution of projects with  $k = 3$  learning types  $(L_0, L_1, L_2)$ .

The model is, then, the conditional probability based on the difference equation we have, i.e. the replicator dynamics, with the Dirichlet distribution representing our prior knowledge about the parameters. Given the previous state  $L(t - 1)$ , the conditional density of the current state is

$$f(L(t) | L(t - 1)) = \frac{\Gamma(N)}{\prod_{i=0}^2 \Gamma(NZ_i(t))} \prod_{i=0}^2 L_i(t)^{NZ_i(t)-1}.$$



The next step is finding the conditional log-likelihood function for the maximum likelihood estimation procedure by summing the log of the conditional density for the whole period, i.e. from  $t_1$  to  $t_{58}$  (denoted by  $T$ ):

$$\begin{aligned}
\ln \ell &= \sum_{t=1}^T \ln \left[ \frac{\Gamma(N)}{\prod_{i=0}^2 \Gamma(NZ_i(t))} \prod_{i=0}^2 L_i(t)^{NZ_i(t)-1} \right] = \\
&= \sum_{t=1}^T \left[ \ln \frac{\Gamma(N)}{\prod_{i=0}^2 \Gamma(NZ_i(t))} + \ln \prod_{i=0}^2 L_i(t)^{NZ_i(t)-1} \right] = \\
&= \sum_{t=1}^T \left[ \ln \Gamma(N) - \ln \prod_{i=0}^2 \Gamma(NZ_i(t)) + \ln \prod_{i=0}^2 L_i(t) \cdot (NZ_i(t) - 1) \right] = \\
&= \sum_{t=1}^T \left[ \ln \Gamma(N) - \sum_{i=0}^2 \ln \Gamma(NZ_i(t)) + \sum_{i=0}^2 \ln L_i(t) \cdot (NZ_i(t) - 1) \right] = \\
&= T \ln \Gamma(N) + \sum_{t=1}^T \left[ - \sum_{i=0}^2 \ln \Gamma(NZ_i(t)) + \sum_{i=0}^2 \ln L_i(t) \cdot (NZ_i(t) - 1) \right] =
\end{aligned}$$

$$\ln \ell = T \ln \Gamma(N) + \sum_{t=1}^T \sum_{i=0}^2 \left[ - \ln \Gamma(NZ_i(t)) + \ln L_i(t) \cdot (NZ_i(t) - 1) \right].$$

This procedure eliminates products and exponentials, simplifying the calculations of partial derivatives in the process of optimization. I keep following Magnani, Friedman and Sinervo (2015), using a simplified version of their Matlab code. They use the *fmincon* function from the *optimization toolbox* with the *active set* algorithm. This algorithm maximizes  $\ln \ell$  numerically, searching the parameter vector  $\theta = (N, W_{00}, W_{01}, \dots, W_{22})$  that best accounts for the available data. The iteration process starts at  $W_{ij} = \frac{1}{9}$  and  $N = 18$ , and the function satisfies the

constraints  $N > -1$ ,  $\sum_i \sum_j W_{ij} = 1$  and  $W_{ij} \geq 0$ . As pointed out in section 5.1, we also know that the average  $\bar{W} = \sum_{i=0}^2 L_i W_i$  and the fitness of each learning type ( $W_i$ ) at a given state  $\mathbf{L} = (L_0, L_1, L_2)$  is weighted by the shares:

$$W_0 = L_0 W_{00} + L_1 W_{01} + L_2 W_{02}$$

$$W_1 = L_0 W_{10} + L_1 W_{11} + L_2 W_{12}$$

$$W_2 = L_0 W_{20} + L_1 W_{21} + L_2 W_{22}$$

One way to validate the estimation procedure is creating a few different fitness matrices, generating data sets from them and running the model to see to which extent the parameters values initially used can be recovered. I successfully recovered the true parameters of several distinct matrices for 58 months. I also run the model with a broad set of initializations, finding the same estimates. Results are discussed in Chapter 5.

The following is the code of the basic model, which I use to find  $\theta$  for the whole portfolio of projects as well as for each subgroup with very little adaptation from the original version. The example displayed runs the whole data. Each estimation requires the main code, e.g. the following `Model_Total.m`, the 3x58 vector with the data of shares, e.g. `Shares_Total.mat`, the `sample_dirichlet.m` file with a function that creates samples for the bootstrapped standard error section, and the code with the conditional log-likelihood model, which is the `learning_model_dirichlet.m`. The original Matlab code is available at:

<https://dash.library.ucsc.edu/stash/dataset/doi:10.7291/D1H59D>

## ***Model\_Total.m***

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%  
%  
% Adaptive Development: The Microgenesis of Development as Adaptive Learning  
% by Gabriel Filartiga  
%  
% Based on:  
% Estimating Payoff Matrices from Time Series Data:  
% The Case of the Lizard Rock-Paper-Scissors Oscillator  
% by Daniel Friedman, Jacopo Magnani, Dhanashree Paranjpe and Barry Sinervo  
%  
% Required files: Shares_Total.mat, learning_model_dirichlet.m,  
% sample_dirichlet.m  
%  
% Reading the data  
clear all;  
load Shares_Total.mat; % contains the dataset shares  
infoz.data.s=shares; % turning data into a nested structure  
%  
% Initial conditions  
w0=ones(3,3)*1/9; % initial values of the w payoff matrix  
delta0=18; % precision parameter N  
theta0=[delta0,reshape(w0',1,9)]'; % MLE theta vector  
F=@(V)learning_model_dirichlet (V,infoz); % dirichlet function  
%  
% Constraints  
A=ones(1,10);  
A(1,1)=0;  
B=1;  
lb=0.00001*ones(10,1); % lower bound  
lb(1,1)=0.01;  
ub=ones(10,1)*0.9; % upper bound  
ub(1,1)=100;  
%  
% MLE  
options=optimset('Algorithm','active-set','GradObj','off','Hessian',  
'off','Display','off','FunvalCheck','off');  
[theta_mle,fval,exfl,out,lambda,grad,H] = fmincon(F, theta0,  
[],[],A,B,lb,ub,[],options);  
%  
% Results
```

```

delta=theta_mle(1,1); % precision parameter N
w=reshape(theta_mle(2:end,1),3,3)'; % payoff matrix
l=fval;

% SE bootstrap
T=58;
y=[];
j=[];
for i=1:100
    s=zeros(3,T);
    s0=shares(:,1); % start with real initial shares
    s0=sample_dirichlet(delta*s0,1); % sampling from dirichlet
    s(:,1)=s0;
    for t=2:T
        alpha=delta*s(:,t-1).*(w*s(:,t-1)/(s(:,t-1)'*w*s(:,t-1)));
        s(:,t)=sample_dirichlet(alpha,1);
        while s(1,t)<0.01||s(2,t)<0.01||s(3,t)<0.01
            s(:,t)=sample_dirichlet(alpha,1);
        end;
    end;
    infoz.data.s=s;
    F=@(V)learning_model_dirichlet(V,infoz);
    [theta_mle,fval,exf1,out,lambda,grad,H]=
    fmincon(F,theta0,[],[],A,B,lb,ub,[],options);
    y=[y,theta_mle];
    if sum(isnan(theta_mle))>0
        j=[j,i];
    end;
end;
y(:,j)=[];
my=mean(y')';
dy=std(y')';
se=reshape(dy(2:10,1),3,3)'; % SE matrix
sedelta=dy(1,1); % precision parameter N
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

```

### *sample\_dirichlet.m*

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%  
function theta=sample_dirichlet(alpha,N)  
k=length(alpha);  
theta=zeros(N,k);  
scale=1;  
for i=1:k  
    theta(:,i)=gamrnd(alpha(i),scale,N,1);  
end;  
S=sum(theta,2);  
theta=theta./repmat(S,1,k);  
theta=theta';  
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

### *learning\_model\_dirichlet.m*

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%  
function y = learning_model_dirichlet (theta,infoz)  
% Reading the data  
s=infoz.data.s; % data  
theta=theta'; % MLE theta vector  
d=theta(1,1);  
w=theta(1,2:10);  
w=reshape(w,3,3)';  
%  
% Preliminary computations  
T=size(s,2)-1;  
wbar=sum(s.*(w*s),1);  
a=d*s.*(w*s)./(repmat(wbar,3,1));  
wbar=wbar(:,1:T);  
a=a(:,1:T);  
S=s(:,2:T+1);  
s=s(:,1:T);  
%  
% Compute log-likelihood function  
y=(size(a,2))*(gammaIn(d))+sum(sum(-(gammaIn(a))+log(S).*(a-1),1),2);  
y=-y;  
end  
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

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