

Padgett & Powell's intro chapter (first draft)

May 23, 2003

Market Emergence

[In this unwritten first section, we will outline “dependent variable” of book:

market emergence on three levels/senses:

market = mode of competition & interrelation

organization = production of new org. forms (novelty)

regime = economic-political-social regulation.

(emphasize our unusual overlay definition of “market”, to set stage.)

with brief but sexy illustrations/pointers,

both to “real world” and to upcoming chapters/cases in book,
including discussion of regime transformation.]

Dynamic Multiple Networks

Our theoretical approach to the historical emergence of markets is dynamic multiple networks. We analyze autocatalytic feedback both among economic networks within markets and between economic networks and those social and political networks in which market actors are embedded. Feedback dynamics among multiple networks are crucial, we claim, not only for the reproduction of existing economic markets but also for the generation of organizational novelty and for tipping across economic regimes.

Markets and industries are themselves economic networks. In particular they are compositions or overlays of economic networks of various kinds: trading, investment and credit, inter-firm contracts, partnerships, careers. In most academic research these various networks are typically peeled away and examined separately, thereby suppressing the fact that all of these networks provide lattices of support for the others. Reproduction in and of these networks requires feedback from the others. Like any other highly interactive non-linear system, such congeries of economic networks have many dynamic potentials: converging to stable (though complicated) fixed points, cycling, tipping via bifurcations, even descending into chaos. Multiple dynamic trajectories are almost always latent in any highly interactive system, no matter how much in equilibrium¹ they appear to be. The goal of this book is to explore, both analytically and empirically, the relationship between multiple-network architectures of economic markets and the dynamic trajectories latent within them.

Social and political networks are of deep interest in their own right. From the perspective of emerging markets, however, the functional roles of “social context” are two-fold: generation and regulation. Organizational novelty is possible through the structured mechanisms of recombination and refunctionality, through which organizational ideas and models are transposed from one domain to another.² On the other hand, without homeostatic regulation (i.e., negative feedback) of this process of transposition and reproduction, there would be no system to observe in the first place. For analytic simplicity it is convenient to bracket social and political networks as “exogenous” to economic networks,³ but ultimately it is the co-evolution of the economic with the social and political that is of crucial interest, especially in the study of historical transformation. Scholars ignore co-evolution of economic with social and political networks at the serious cost of making large macro-historical questions about market emergence and transformation unanswerable.⁴ Social and political networks shape the topology of the trajectory space on which dynamic economic-network congeries evolve.⁵

To operationalize these concepts, first we sketch “dynamic multiple networks” and their feedback for Padgett’s historical case of Renaissance Florence. Then we sketch

¹ Actually this is called “meta-stable” equilibrium.

² Cognitive scientists might be tempted to call this transposition process “blending” (Turner and Foucaquier, 2001).

³ This simplification only works if networks operate and reproduce on different time scales.

⁴ Except through the historically naïve device of teleology.

⁵ And vice versa.

“dynamic multiple networks” and their feedback for Powell’s empirical case of biotechnology. Together these applications will illustrate the empirical generality of our theoretical approach, which then will be further utilized in the series of cases featured in this volume.

A. Dynamic multiple networks in Renaissance Florence:

To operationalize our approach for the case of Renaissance Florence, first we shall describe the social and economic networks at issue there; second we shall describe the feedback mechanisms that strike us as crucial to Florentine network co-evolution; and finally we shall sketch the consequences, to be developed further in two empirical chapters, of network dynamics for actor emergence, for regime transformation, and for the creation of organizational and technical novelty.⁶

(1) Multiple networks

Before discussing feedback dynamics in Florence or any other case, one has to specify the multiple social networks at issue. Abstracting from empirical work, the core Florentine social relations to be explained, according to Padgett, are the following:

Table 1. Types of network ties

	ECONOMIC DOMAIN	KINSHIP DOMAIN	POLITICAL DOMAIN
Constitutive ties	partnership + apprenticeship = “firm”	father-child + marriage + close neighbor = “family”	alliance + client = “faction”
Relational social-exch. (“gifts”)	investment & credit	wives	scrutiny votes (for election to office)
Transactional flows	trade	children, plus trade and favors (not specialized)	political favors (both private and public legislation)

⁶ This after all is a central reason for being interested in the Renaissance to begin with.

In this representation, there are three domains of activity: economic, kinship, and political. While not covering everything the Florentines did, these domains of activity span a fairly high percentage of total Florentine life. These three activities were implemented primarily through the networks, organizations, and transactional flows listed in table 1. In Renaissance Florence (and in biotechnology as well), it is crucial to realize that organizations and networks were not completely specialized: In addition to the primary economic organizations and networks, economic trade also flowed through kinship and occasionally through political networks. And in addition to political networks, political favors flowed through kinship and sometimes through economic networks.⁷ Florentines were opportunistic, pursuing multiple activities via whatever means were at their disposal. This spillover is one basis for multiple selection and dynamic feedback across networks.

The table also lists three types of network: constitutive ties, relational social-exchange “gifts”, and transactional flows. Constitutive ties are the building blocks (often legally contractual) of formal organizations: firms, families, and factions. Relational social exchanges are the “gifts” people and organizations give to each other to make each other productive:⁸ investments and credits to make firms capable of trade, wives to make male patrilineal capable of producing children, and electoral votes to make politicians into office-holders. Transactional flows are the objects or “things” (including money and legislation) being transformed and exchanged by participant activity.⁹ Keeping these three levels of social-network analysis distinct is key in order to parse the individual steps in selection feedback: constitutive organizations are made productive through relational “gifts”, which are generated out of transactional flows, which are induced by organizational activity.

The first two levels of Florentine social networks, constitutive and relational, are assembled into a full multiple-network ensemble in figure 1. As already mentioned, at the level of transactional flow multiple networks are linked across domains by spillover or multi-functionality. Similarly at the constitutive and relational levels, multiple networks are linked across domains by the fact that many of the same people participate in all of them. People are links between ties.¹⁰

Because of this interconnected topology, tie formation in one domain is often influenced by structural position in other domains.¹¹ Indeed in Florence, this is

⁷ Finally, affection and friendship (as well as enmity) flowed through economic and political ties. Florence was hardly the world of the impersonal market, found in introductory economics textbooks.

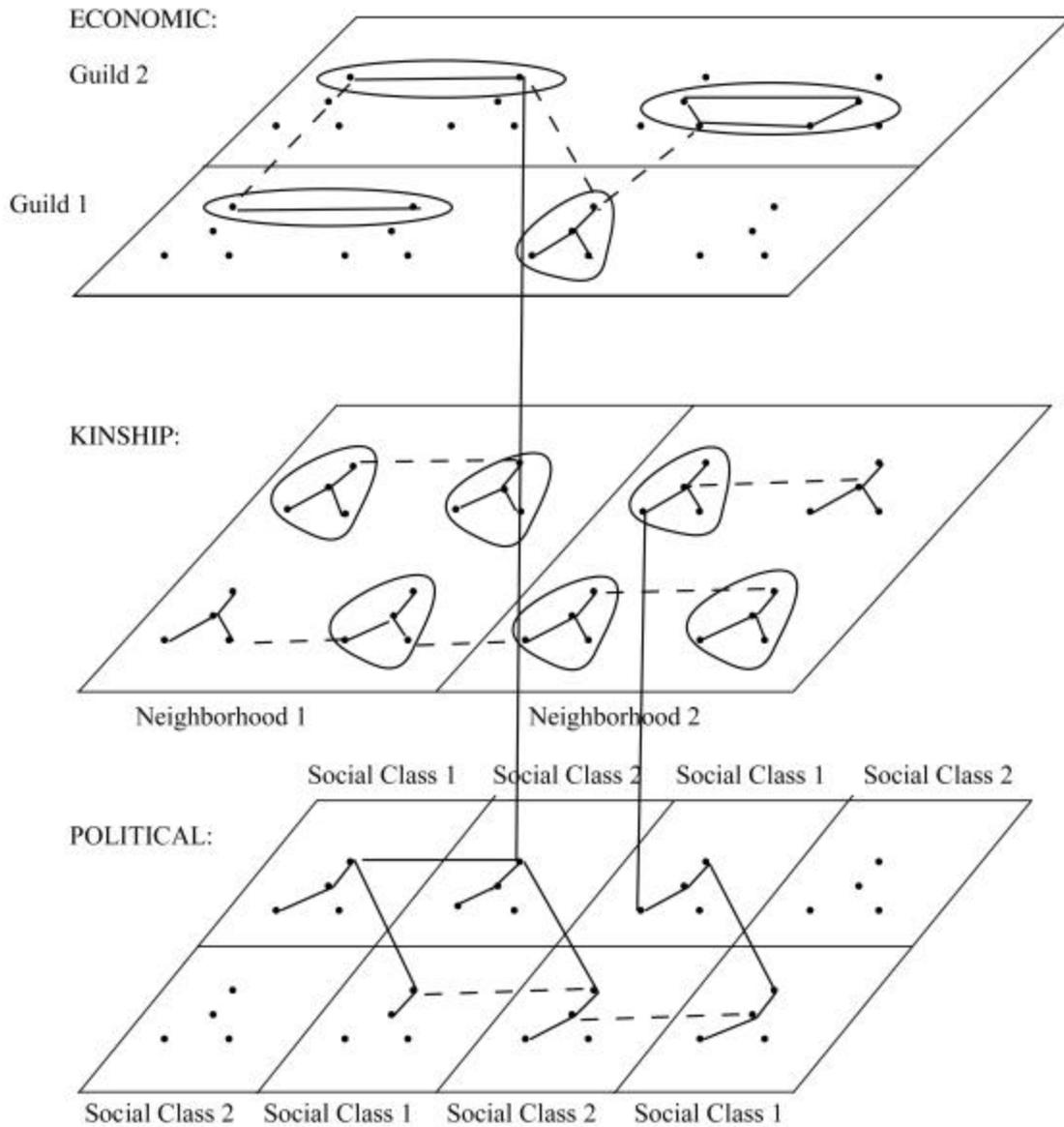
⁸ In anthropological interpretation, this is also viewed constitutively: actors “make each other” through social exchange. We accept this interpretation, even though we do not believe the social-exchange concept applies only to primitive tribes, where it was first discovered.

⁹ Not being patrilineal Florentines, it may puzzle some readers to see “children” under kinship-based transactional flow. In addition to daughters flowing to other families as wives, however, sons could also flow to firms as apprentices and to factions as clients. As adults these people became actors, but as children they were objects of exchange (“things”) between their Florentine fathers.

¹⁰ In social network analysis, this is called duality: people are connected by ties, but also ties are connected by people.

¹¹ This is what sociologists call “embeddedness”.

Figure 1. Multiple-network ensemble Renaissance Florence



Note: (a) Solid lines are constitutive ties. Dotted lines are relational social exchanges. Oblongs are formal organizations (families and firms.)

(b) People in multiple roles are verticle lines connecting corresponding dots in the domains of activity in which people are active. (Only two are shown for illustration.)

empirically the case. Attractiveness as a potential marriage partner was influenced by the husband's and his family's political offices and economic firms. Election to and effectiveness within political office was influenced by kinship roots and by business success. And business success in turn was affected, especially in times of economic trouble, by the investment and "insurance" of kin and also by political access.

In addition to multiple-network overlay, figure 1 also illustrates the Florentine institutional categories within which these economic, social, and political network ties formed. At a coarse-grained level of resolution, these were the cognitive classifications within which Florentines thought about their own and about others' interests. For the economic domain, the primary Florentine institutional classification was the guild. For the kinship domain, it was the neighborhood (especially *gonfalone*). And for the political domain, it was social class.¹² Operationally these categories defined eligibility for participation, not participation itself.¹³ To be a guildsman meant to be eligible to participate in that industry; to be permanently living in a Florentine neighborhood meant to be eligible to be or to become a patriline; to be a certain social class meant to be eligible for election to (certain sets of) Florentine state offices. Like networks themselves, these institutionalized eligibility categories could become multi-functional: for example, Florentine "guild corporatism" built guild membership into the definition of political citizenship. Because these institutionalized-categories-cum-cognitive-classifications affected the scope for action, and others' attributions, Florentines treated membership in and mobility through these categories as heavily freighted with status and "identity" connotations.

(2) Feedback mechanisms

Having sketched topology, for understanding dynamics it is crucial to identify developmental feedback mechanisms, linking both multiple domains of networks and multiple levels of network analysis. One simple such mechanism, consistent with both quantitative and qualitative reports about Renaissance Florence, is brokerage.

Transactional flows are not explicitly represented in figure 1, but Padgett has shown statistically (Padgett and McLean 2003, plus two chapters below) that the formation of economic partnership, credit and trade networks among Florentine firms was deeply affected by the "social-embeddedness" matrix of kinship, neighborhood, and political relations in which they developed. A brokerage process, in which information and recommendations about potential economic exchange partners are passed through multiple "trusted" social relations, can account for these statistical (and textual) observations.¹⁴

¹² Florentines, at least during the republican period studied by Padgett, conceptualized "social class" in terms of the date in which your patriline ancestor first obtained leading political office (especially in the Priorate or city council).

¹³ In terms of the diagram, "active participation" is the same as forming a network tie.

¹⁴ We develop our discussion using economic exchange as the reference, but the same brokerage statements hold for the search for potential political allies or for the search for potential marriage partners.

On the transactional-flow or trade level of analysis, such a brokerage process might work like this: partners of a given firm with a target product to buy or sell consult others they know for information about relevant target firms, with whom they (or their contacts) have had experience. Early in a searching partner's career, such informational networks might be restricted to kin or other inherited constitutive ties. But over time with industry experience, such informational networks, composed out of both constitutive and relational ties, grow and expand to the point where that partner starts to have value as a broker to others, in addition to just consuming *raccomandazioni*. Once searchers begin to present investment and credit "gifts" to the broker, in order to create bonds of obligation, then the brokerage system becomes self-sustaining. And the role of the broker expands from passive search algorithm to proactive match-maker.

On the next relational level of analysis, we can conceive of brokerage as operating similarly, except not in such a top-down a fashion.¹⁵ That is, a Florentine could search for businessmen in which to make investment and/or credit "gifts" either indirectly through chains of constitutive ties (for example, the brother of a political ally) or directly through "thickening" of successful past trade into credit via reciprocal trade or repeat trading. Add the competition of multiple brokers, and a selection dynamic of relational-transactional feedback is induced: Relations generate trading business through the brokers, who gain the transactional wherewithall to make further investments. This relational feedback process runs, moreover, on the slower time-scale "switching tracks" of constitutive ties.

At the formal level of constitutive ties, our general image of the brokerage process persists, but with the added complication of "appropriate matching rules." Economic partnerships, marriages, and political alliances were too weighty in the lifecourse of a Florentine for trial-and-error learning with feedback to be reliable. More-or-less socially standardized¹⁶ models or protocols of appropriate matches emerged to benchmark options and thereby to induce conscious deliberation. These normative standards, to be discussed in the next section, vary by historical regime and serve as "lock-in" regulatory devices to regulate the smooth reproduction of an existing multiple-network system that emerged dynamically for other reasons.

Viewed as an ensemble, this multiple-network brokerage process is an autocatalytic system, in which brokers catalyze other network relations, but these "catalysts" are themselves produced by the reproductive system. At a fine-grained level of resolution, brokers are the third parties ("the judges") who set and later enforce the normative framing of potential interaction partners. Through both indirect information and direct face-to-face introductions, brokers shape the "faces" partners present to the other. Hence systemically, the reproduction of "culture," in the form of appropriate matching rules, and the reproduction of "elite control," in the form of sets of interconnected brokers, are intimately related.

¹⁵ By "top-down" in this context we mean transactional matching being processed through the "higher" lattices of constitutive and relational ties. The weighting of exactly which constitutive and relational ties are used for economic-trading search we conceive as parameters that historically vary by regime.

¹⁶ Or at least boundedly heterogeneous.

Figure 2. Dynamic feedbacks in Renaissance Florence

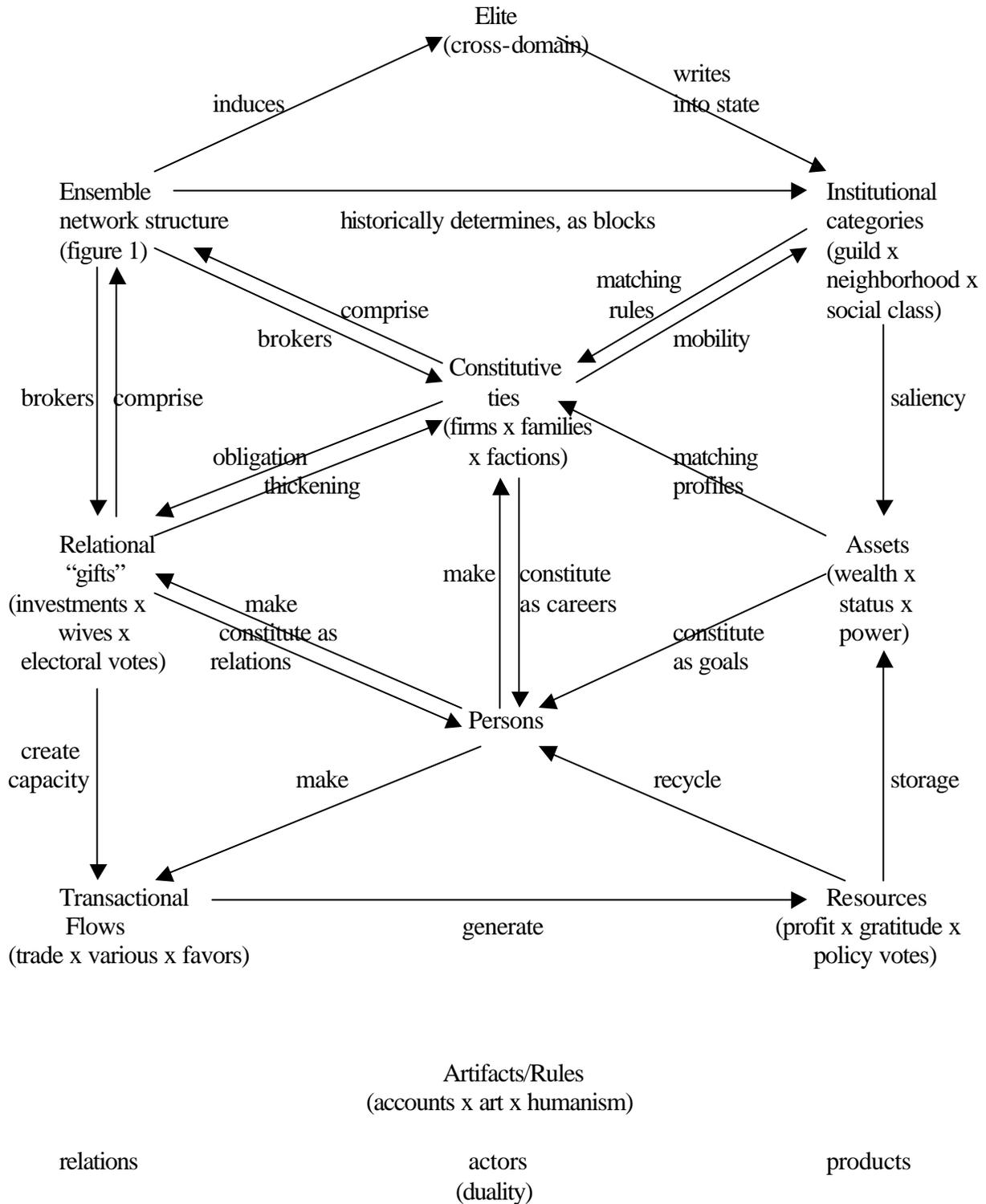


Figure 2 assembles all the dynamic feedbacks discussed in this Florentine section into a “meta-architecture” for a coherent representation of multiple-network co-evolution in Renaissance Florence. This diagram is not a model per se, it is a framework for the construction of alternative possible dynamic-feedback and constructivist models. Depending upon the phenomena of interest, this framework can support the modeling and analysis of dynamic multiple networks, of emergent actors, and of tipping among political-cum-market regulatory regimes. Multiple economic, kinship, and political domains are embedded in the diagram through the three instantiations of each of the components. While different historical regimes are not explicitly identified in the diagram, they can be conceived as sets of specific rules or models that operationalize these feedbacks in different concrete ways – with different dynamic trajectories of potential crisis and co-evolution latent within each of them.

The left-hand column of the figure assembles transformational relations, at various levels of analysis. These are the interactional rules or activities used in creating and transforming products. The right-hand column of the figure portrays categories of objects, again at various levels of analysis. These are the products, both material and institutional, being created and transformed. Actors, in our view, are compositions or intersections of these two columns (“duality”): they are objects produced by the system with the capacity to transform the system. “Organizational novelty” occurs when new actors with new transformational capabilities emerge. This process can occur at any level of analysis: formal organization, person, or city elite.

(c) Actor emergence

Fourteenth and fifteenth century Florence is called “the Renaissance” in large part because new forms of organization, technology, and ways of thinking were created there (and in the rest of northern Italy). Emergent actors, relations, and products therefore are crucial first to represent and then to explain within our dynamic-multiple-networks framework. The case of newly emergent organizational forms in Florentine banking, which revolutionized international finance, will be discussed in chapter 4. Here instead we focus our discussion on a more micro level of analysis: the social construction of persons.

Table 2 describes a “person” in our framework.¹⁷ For us, a Florentine person has three multiple roles: economic, kinship, and political.¹⁸ Each of these roles has a corporate or “public” face, visible to outsiders observing and discussing the person in the role, and a relational or “private” side, visible only to the direct participants in role interaction. The public corporate face presents summary statistics or indicators of the corresponding detailed activities taking place in the private relational sides of persons.

¹⁷ In the representation of figure 1, a person is a vertical line, spanning activity domains.

¹⁸ For non-historians it is important to mention that bankers and other guildsmen were not specialized in business. They were typically very active in politics as well, both during their terms as businessmen and especially later in life after much of their business career was behind them. This was made possible by the republican government structure of Florence, which specified short terms (often two months) during which businessmen and others would rotate into state service and then out again. Republicanism therefore was one institutional structure that lay behind the social emergence of “the Renaissance man.”

Table 2. The social construction of persons

A Person is dual = Corporate (“public”) self + Relational (“private”) self

KINSHIP: Institutional membership Biography Assets	NEIGHBORHOOD FAMILY STATUS	{kinship ties: patrilineal + in-law} past beneficence = ? econ. credits + ? pol. credits
ECONOMIC: Institutional membership Biography Assets	GUILD ECON. CAREER ? Experience WEALTH	{past partnerships} + {econ. credits} = economic access to trade personal wealth + mobilizable wealth through access
POLITICAL: Institutional membership Biography Assets	SOCIAL CLASS POL. CAREER ? Experience POWER	{past alliances} + {pol. credits} = political access to favors personal office + controlled offices

These public features are what others observe, discuss, gossip about, and/or decide upon when thinking about persons. In contrast, the private relational sides are what persons are actually doing, in their interactions with others. Whether public-face variables are interpreted as the “goals” of the private-side actions, or whether they are interpreted only as post-hoc summary indicators of private-side actions, is an ambiguity about which the framework itself is agnostic. Readers can interpret goals as motivational or as post-hoc accounts, as they choose.¹⁹

Western mythology about individualistic autonomy notwithstanding, activities of persons are jointly under the control of persons and their interaction partners. The “private side” of persons thus are deposits of past and present interactions, encapsulated through memory and learning. The right-hand column of table 2 presents our Florentine version of the general social-exchange conception of persons “making” each other.²⁰ The framework is agnostic about whether interactionist construction of persons is a conscious or an unconscious process, although of course this would matter in detailed implementation.

Iterated through time, sequences of interactions cumulate into careers.²¹ Placing these interactions into the full dynamic feedback of figure 2, one can see that careers of persons are generated by the reproduction of networks through time. The move of a person from tie to tie is the inverse of the move of a tie from person to person. In transitional multiple-network systems, not yet settled down into regimes, sequences of network moves by persons are too disorderly to be worthy of the label “career.” But an orderly reproduction of multiple-network ensembles generates routinized channels of move sequences for persons. These channels are the social foundation for a person’s cognition of his or her own future, once pattern-recognized by that person’s perceptual apparatus. Rational planning by individuals in our framework presupposes the stabilization of multiple-network ensembles into regimes.²²

Constitutive ties – like economic partnership, patrilineal inheritance, marriage, and political alliance – are the backbones of multiple-network reproduction. Given brokerage, relational social exchanges and transactional flows grow up and around around these core constitutive networks, which regulate those flows thereby. Regulation of constitutive-tie formation itself, therefore, is foundational for system reproduction through time. This is where our “normative matching rules” come in. Given the public faces of persons, constitutive-tie matching rules prescribe (once they crystallize into

¹⁹ Our own inclination would be to interpret this endogenously as a dynamic systems question. Namely, start with the presumption that public-face variables are merely summary indicators of private interactions, without motivational significance. But as the system of interacting persons converges on coherent and consistent public-face “protocols” of coordination, these interface variables select for persons who proactively pursue them, in order to ensure system reproduction in the face of selection pressure. Goals of persons, in this interpretation, are system controls (cf. Padgett and Ansell 1993).

²⁰ This is the meaning of “constitute” in figure 2.

²¹ Across roles, careers in turn concatenate into biographies.

²² Rephrasing footnote 19 in other language: rational planning by individuals is a consequence of effective social reproduction and control. Stable organization creates a world simple enough for human minds to comprehend and thereby to become rational (cf. March and Simon 1958).

existence) the complementary profiles of public faces that are appropriate to match into constitutive ties. “Normal” in the sense of statistical turns into “normative” in the sense of prescription once collectivities of persons recognize the patterns in network-ensemble reproduction and start to enforce them.

A very simple example of how this works is as follows. Two persons with publically known features of guild membership, career experience, and wealth²³ consider whether to form an economic partnership, having discovered each other through a brokerage process like that discussed above. If they decide to go ahead, subsets of these two persons’ features will be merged to form the firm, as in the diagram below: the firm is an overlap of the two persons. (Conversely over time the two partners, through the agency of their firm, “make” each other, in career as well as in wealth.)

	Economic Partnership (= Firm)		
Person 1			Person 2
Guild ₁	Industry ₁	Industry ₂	Guild ₂
Experience ₁	Access ₁	Access ₂	Experience ₂
Wealth ₁	Corpo ₁	Corpo ₂	Wealth ₂

Many idiosyncratic factors could be relevant to any particular joint choice of partnership, but social models relevant in certain times and social places establish benchmarks or standards for how two persons’ portfolios of public faces are evaluated and matched. Such role models are often imported from the social context of other networks surrounding the potential partnership. For example, if existing partnerships in the social context of two potential partners were often “like father and son,” then a normatively appropriate matching rule might be: {same guild; high experience coupled to zero experience; high capital coupled to zero capital}. If the statistically frequent role model instead were “like master and apprentice,” then a normatively appropriate matching rule might be: {same guild; high experience, with some experience; high capital, with zero capital}. If the role model instead were “like father-in-law and son-in-law,” then a normatively appropriate matching rule might be: {different guilds; no experience, with moderate experience; high capital, with no capital}. And so forth. (See Padgett (2001) for elaboration and application to specific time periods in Florentine economic history.) The point here is simply that a translation from normal to normative regulates the reproduction of constitutive ties via the construction of social standards or

²³ We consider only these three economic variables for simplicity of illustration. In reality any of the nine public-face variables listed in table 2 could be relevant in the economic partnership decision. Indeed Padgett and McLean (2003) demonstrate statistically that many of these additional non-economic variables (especially family, neighborhood and social class) indeed were relevant to economic partnership choice in 1427.

“role models” of evaluation. Such normative evaluation locks in the reproduction of multiple-network ensembles into what we call a stable regime.

Social-organizational roles for economic partnerships could be evoked by numerous mechanisms, but a prominent one is the brokerage process itself. The normative frame for two potential economic partners facing each other would be one thing, for example, if the broker who originally brought them together was their father, another if he were their neighbor, yet another if he were acting as a member of the political elite. This is like catalysis in chemistry. Concatenation of brokerage through multiple-network ensembles thus generates its own self-organizing regulation.

Brokers passing names around to other brokers also generates a second-order regulation mechanism, more or less automatically – namely, convergence on a shared “hegemonic” classification of others’ identities. Through this second-order mechanism of attribution as well as through the first-order mechanism of catalytic framing, the elites thrown up by multiple-network ensembles regulate constitutive-tie reproduction. When regimes are reproducing smoothly, non-elites self-fashion themselves into elite categories, transforming those received categories into their own goals, through means of their mobility and careers through constitutive ties. Multiple networks of transformational activities thereby generate public-face careers, private-side relational selves and hence persons as a means to their own reproduction.

(d) Regime transformation

A processual view about the construction of organized actors – be these persons, formal organizations or elites – is a prerequisite to any understanding of the emergence of organizational novelty. In the multiple-network framework, a key mechanism for the generation of novelty is re-functionality – namely, the transposition of organizing models or logics from one domain of activity or application to another. For example, organizing economic partnerships “like a father and son,” whether or not partners were literally father and son.²⁴ Sometimes transpositions may displace preexisting organizing logics through a process of competitive selection. Often, however, transpositions can be blended into hybrids that reproduce. Reproducing hybrids may provide incremental fodder for the adaptation of an existing system, or they may transform the system itself, depending upon whether more than one level of analysis is affected by the reproduction of the hybrid.²⁵

The overlay architecture in multiple-network ensembles shapes “the topology of the possible” (Fontana 2003) diffusion paths for re-functionality. The statistical likelihood of various transposition trials is related to the statistical frequency of corresponding multiple-role combinations. Through this simple topological fact, “innovation potential” is related to the composition principles that link networks.

²⁴ For a late fifteenth-century Florentine example of economic traders behaving in their letters as fictive kin see the opening pages of Padgett and McLean (2003).

²⁵ Wagner and Altenberg (1996), building upon Simon (1968), discuss modularity as one architectural feature shaping whether a hybrid is incrementally adaptive or revolutionary (quite possibly in a destructive direction) in its evolutionary effect.

But of course a transposition trial does not guarantee success. For success, there must be reproduction and selective growth of the organizational novelty. This in turn depends upon how the novelty fits into (that is, is amplified or dampened by) the multiple-network dynamic feedbacks listed in figure 2. Novelties are readily adopted if they work for existing persons, if they work for existing formal organizations, and if they work for existing elites. But the consequentiality of such incremental adaptations for the feedback system itself is likely to be modest.²⁶ In contrast, innovations that diffuse and lock-in on two of these levels so strongly that they re-key and transform feedbacks in the third are apt to be of great historical interest, even if they are relatively infrequent.

In a multiple-network context, innovations that are multi-functional have especially pregnant potential in this regard. Spillover effects mean that all organizational logics, innovative or old, operate in multiple selection environments. For example, the fact that kinship is used sometimes to produce investment, as well as to produce children, means that family structures operate within economic as well as within biological and social-status selection domains. An important consequence is that, even though one particular family structure may be superior to another from a specialized perspective, the non-optimal but more robust one may come to dominate in an opportunistic world, in which people pursue multiple objectives through whatever organizational tools are at hand.

What multiple selection environments imply for the dynamics of absorbing or rejecting transformative novelty is knife-edge: On the one hand, most multi-functional innovations, including re-functionality transpositions, are selected against because they likely fail (relative to the status quo) from at least one perspective. Indeed the more multi-functional it is, the more perspectives from which it can be judged inferior. On the other hand, if by rare “chance” such a multi-functional innovation is absorbed by the system, it creates another channel between networks that permits dynamics from one domain to cascade into other domains, possibly with reorganizing or tipping potential. Often these dynamic cascades lead only to contradiction and chaos. But occasionally they may tip the multiple-network system from one basin of attraction to another. The key to such nonlinear effects is whether adoption not only transforms practice in the original domain but also transforms the catalysis of others’ practices. In the brokerage example discussed above, this would mean a new form of business partnership transforming not only the way that individual firm did trade, but also the ways in which other firms traded with each other, using that firm as broker.

This topic of innovation cascading through linked multiple networks is of more than academic interest for those who study Florentine history. The essence of the term “the Renaissance” is that innovations did not just happen in isolation, one at a time, in fourteenth and fifteenth century Florence. The most gripping feature of the case, from the perspective of the production of novelty, is that Florentine innovations cascaded from one domain to another: from politics (republicanism) into economics (international finance and accounting) into art (linear perspective) into philosophy (civic humanism and

²⁶ See Fontana (2003) on neutral networks for one possible counter-argument to this intuition.

Machiavelli). A new Western conception of the autonomous, goal-oriented master of his own fate, a flattering self-conception still powerfully influential to this day, was possibly the ultimate consequence of this chain of innovations.²⁷

In this book, “regime transformations” are multiple-network tipping in which the constitutive rules and feedbacks that produce persons, formal organizations and elites themselves are altered. When regime transformations are observed in our cases, the primary mezzo-level processes we see that produced this tipping are dynamic cascades, re-functionality and multivocal hybridity. In the specific Florentine example to be discussed in chapter 4, regime transformations like the Ciompi revolt were highly tumultuous, dramatic and even bloody affairs, in which people, firms, and elites in one form or another were killed. Other cases in this volume are not necessarily as violent as this. Violent or not, the analytic keys to all of us in analyzing these regime-transformation episodes are not triggering incidents, which are historically quite variable, but rather are the structural poisedness of multiple-network architectures to tipping, to begin with, and the cleavages and conflicts generated by the tipping, once tipping has begun.

Tipping without regulation is quite possibly transient. So the final part of our regime-transformation analysis will be institutional lock in. To stabilize reproduction and hence to observe a “new system” in the first place, cascading network tipping must be channeled into more permanent institutions, which regulate the dynamics. Multiple-network tipping itself throws up and generates new forms of elites – either outside challengers, or reorganized versions of old elites, or (often) hybridized mixes of these two. Blockmodeling provides one social-network statistical technology for detecting such emergent elites in formation.²⁸ Once formed, victorious subsets of these new elites become the agents locking in the results of the network tipping, which produced them, into formally institutionalized categories.²⁹ In Renaissance Florence these categories – guild, neighborhood, social class – were inscribed into a highly participatory republican state via citizenship and elections (Najemy 1982). Because the state thereby became so centrally and intimately involved in the daily economic and kinship,³⁰ as well as the political, lives of its citizens, election to state office carried status and “identity” overtones central to Florentine interactions with each other. Thus the Florentine state regulated the feedbacks outlined in figure 2 not just through policy directives from above,³¹ but much more deeply by framing the conceptual categories in which Florentines classified each other.

²⁷ This Burckhardt thesis (1860) of the “Renaissance rise of modern individualism” is certainly wrong in the extreme form Burckhardt himself posed it. But a suitably modified form remains highly contested among modern Florentine historians.

²⁸ Grounded in the notion of structural equivalence (Lorrain and White 1971), blockmodeling was invented by Harrison White and co-workers (White, Boorman and Breiger 1976, Boorman and White 1976). Padgett and Ansell (1993) used this multiple-network statistical technique extensively in their network analysis of the political rise of the Medici.

²⁹ Losers might call this repression.

³⁰ Even getting dowries to marry daughters was intimately bound up with state-finance bonds (Molho 1994).

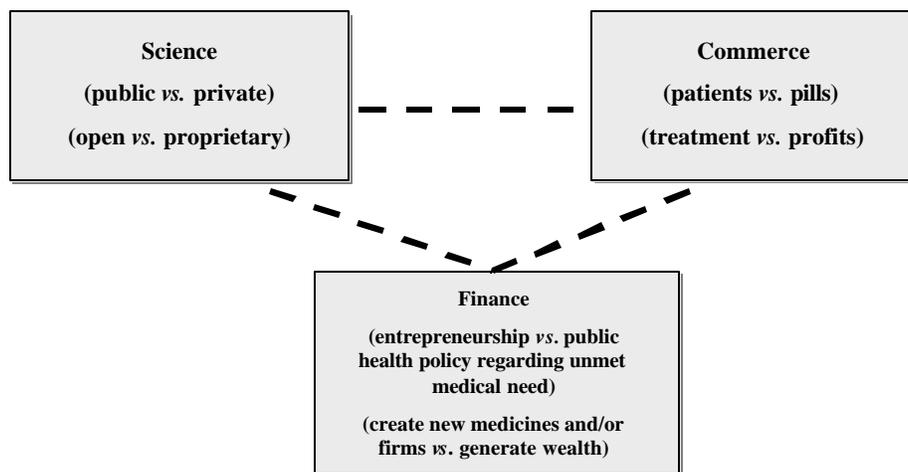
³¹ Indeed Florence was a relatively “weak state” from the narrow perspective of powers of legal enforcement. The boundary between “the state” and the citizens (especially the elite citizens) being regulated was porous indeed.

B. Dynamic Multiple Networks in the Life Sciences

The process of creating and bringing new medicines to market is lengthy, expensive, and highly uncertain.³² Successful drug development entails three aspects - - the discovery process, the clinical translation of novel science into a viable commercial medical product, and the securing of financing to fund R&D, clinical testing, and commercialization. We conceptualize these activities as three analytically separate domains of Science, Commerce, and Finance. To a considerable extent, no single organization in the life sciences sector possesses all these relevant skills in either sufficient quantity or variety, hence the need for participants in the field to collaborate with one another. These capabilities are associated with different types of institutions: universities and research institutes are dominant in the world of basic science; large multinational pharmaceutical firms are central to the domain of commerce, but they have been joined over the past three decades by the “new” biotechnology firms; and finance, consisting of both public equity market financing of firms and government funding of biomedical R&D.

Each of these domains has inherent tensions, captured by their public and private “faces.” Figure A summarizes the tensions that are common in these arenas. The science realm has an open, public side in which access to knowledge is not restricted and is

Figure A: Domains of Life Sciences and Associated Tensions



³² To illustrate, five to eight years from laboratory bench to doctor’s office would be regarded as timely, while cost estimates range from \$200 to \$800 million per new medicine. As for success rate, most firms would be thrilled with a success rate of one out of five new projects; many conventional estimates are on the order of one in fifteen. These figures on time, costs, and odds are rough approximations. A small array of analysts, health economists, and industry experts devote a great deal of attention to these calculations.

accessible to all within the community.³³ But there is also a proprietary side to science in which access is limited, either through network closure or via patents or licenses. The contemporary phrase “intellectual property” captures the extent to which ideas have become commodities. Seen through a public eye, the domain of commerce is medicine, where patients with a vast array of diseases are cared for and treated. Such treatment is, however, costly and herein the commercial face looms large. Pills and profits represent the private side, and since these elements outweigh public health concerns, at least in the United States, we label this domain commerce. Finance also has both a public and private component. Public health policy is translated into research budgets for the National Institutes of Health, which finances basic science and clinical translation aimed at making progress in the treatment and cure of diseases. Nonprofit foundations also play a modest role in this area of funding, through support of work on vaccines, infectious diseases, and other medicines that are regarded as less commercially “viable”. The public equity markets represent the private finance side, where investors allocate their funds to buy shares of companies that generate wealth through the profitable introduction of new medicines. Over the past two decades, venture capital has become a critical component behind the financing of new science-based biotechnology firms.

1.) Multiple Networks

Over the past three decades, the linked, but separate, domains of science, commerce, and finance have grown increasingly integrated. The processes driving this transformation are analyzed in subsequent chapters; here we attend to the cross-realm relationships that developed and triggered a burst of hybrid and novel organizational arrangements. We contend this profound shift is most notably reflected in the emergence of new actors and organizations that signal a growing market conception of science. With this regime transformation, the logics of science, commerce, and finance have become intertwined. To explain this development, we map the multiple networks that criss-cross the life sciences, generating flows of ideas, resources, and property. Individuals form the links between these ties among organizations. We specify the multiple networks in biotechnology in an analogous manner to the mapping of Renaissance Florence. Table B summarizes these relationships.

Transactional flows are things that are exchanged among participants to enhance productivity. In the life sciences, such trades are often formal and contractual. For example, while the coin of the realm in the sciences may be ideas, these ideas are transferred to other parties through licenses or patents. In the financial domain, money and oversight are the key elements that are provided by funders to the parties they

But as with most such statistics, they can be used for political purposes or to justify high costs, hence are best viewed as rough estimates.

³³ We should note that the definition of public and private shifts between Florence and the contemporary life sciences. In Florence, public simply means open to third parties; for the life sciences, public expands to include activities that are both open and considered of wide benefit.

support, and are formalized into partnerships that create new organizations. On the commerce side, exchanges involve clinical trials, manufacturing, or co-marketing arrangements in which patients or pills are the currency.

Table B: Types of Ties in Biotechnology

	SCIENTIFIC DOMAIN	COMMERCE DOMAIN	FINANCE DOMAIN
Constitutive Ties	Co-authorships + scientific collaborations = Invisible College	Product development alliances sum to a market structure of disease categories	Founding teams + Boards of Directors + Syndicates + Review Panels = Different “types” of Investors
Relational Ties	Citations, students	Patent co- assignment, personal ties that create/cement business partnerships	Clientage, sponsorship, access to a fund
Transactional Flows	Ideas/Patents	Patients/Pills	\$/Advice

Relational ties are more open-ended, and embedded in professional relations or friendships. In science, such a gift is a citation or the recommendation of a student for a position. In the commercial realm, joint assignment of a patent represents sharing the fruits of private science labor. The numerous product development collaborations among firms and other organizations are facilitated by personal relationships among employees and the ensuing organizational and political savvy that accrues to veterans of these exchanges. In finance, relational links are expressed by sponsorship and advice.

We conceptualize constitutive ties as the categorical outcroppings of transactional flows and relational gifts. Put differently, constitutive relations are coherent and recognizable (though perhaps only by knowledgeable participants) categories. Flows of ideas and gifts of students and citations are the media of exchange in invisible colleges.

The array of partnerships to develop new medicines for diverse diseases produces a market structure that locates firms as a portfolio of activities across therapeutic categories. The different forms of financial involvement, running from membership on the founding team or board of directors to participation in a venture capital syndicate or the review panel for a federal agency that awards biomedical grants, constitute the broad category of relevant investors. We think it crucial to keep these three types of ties distinct, so that we can chart whether these relationships combine in ways that are either reinforcing or degrading.

2.) Actor emergence.

Many of the accounts of the emergence of the life sciences stress the scientific and technological revolution produced by a series of remarkable breakthroughs in molecular biology (add cites). These arguments emphasize the discontinuity between the older tools of drug discovery, based in organic chemistry, and the novel methods of molecular biology and genetics. This Schumpeterian portrait of a process of creative destruction captures in broad-brush strokes a changed landscape, but lacks the analytical ability to specify which organizations are likely to be most affected by these winds of change. More important for our purposes here, we want to know how such changes have ramifying effects that can possibly lead to the creation of new roles and identities, new organizational practices, and new organizational forms.³⁴ How is it that the social models by which science and commerce are assessed and joined are altered? We maintain that an analysis of the changing logics of multiple network embedding helps explain the emergence of an array of novel organizations and practices that grew out of scientific breakthroughs in the life sciences, which, in turn, fueled further scientific inquiry. At the core of these developments were new conceptions of both science and finance, which initially were viewed as aberrant but came to be regarded as normal. Central to this transformation was not just statistical reproduction in the sense that something unusual diffused and became widespread, but transposition: the initial participants brought the status and experience they had garnered in one realm, and converted these assets into energy in a new domain.

An illustration of how several micro-level networks serve as the conduits for the emergence of new roles and organization is provided by examining a single biotechnology company, Myriad Genetics, founded in 1991, by a scientist at the University of Utah, Mark Skolnick, who was chairman of the department of Medical Informatics. Together with Walter Gilbert of Harvard, a Nobel laureate who himself had started one of the early biotech companies, Biogen, and Peter Meldrum, who came from a venture capital firm with deep experience in the biotechnology, Skolnick fused the worlds of science and finance to utilize the new tools of genomics to search for the genetic basis of diseases. In 1994, Skolnick was senior author on a paper in *Science* that

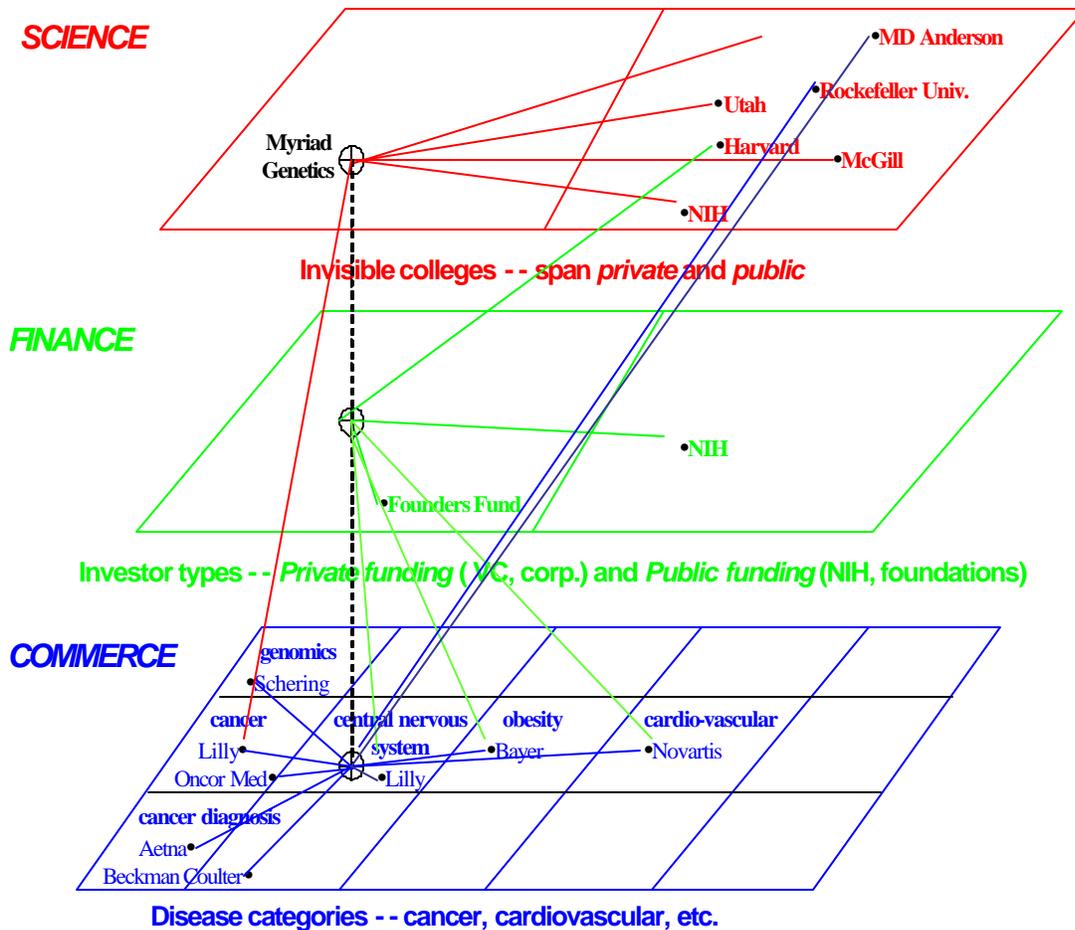
³⁴ A number of scholars are at work on explaining why some pharmaceutical firms were more receptive to molecular biology than others (Henderson; Zucker and Darby; Kaplan, Murray, and Henderson, 2003); why some universities generate more start-up firms and commercial ventures than others (Owen-Smith; Shane), and why some regions and nations have proven more hospitable to life sciences innovation (Owen-Smith et al, 2002); McKelvey, 2003; Casper and Murray, 2003).

generated considerable attention because it suggested a single gene might be responsible for breast and ovarian cancer. Thus the commercial firm, Myriad, became visible in the high-prestige world of scientific publications. Moreover, authorship of the paper brought together 45 researchers from two universities, a government institute, a large pharmaceutical firm—Eli Lilly, and Myriad Genetics. For the pharmaceutical firm, open science publishing, or sharing the news of one's research in *Science*, was an unusual step, a compromise justified by their desire to access Myriad Genetics' capabilities in genomics and the start-up firm's closeness to basic science. This relatively young company used the scientific collaborations and commercial co-development connections diagrammed in Figure G below to bridge the worlds of science, finance, and commerce. In so doing, it pulled proprietary entities into the domain of science, and research universities and hospitals into the commerce realm.

The various partnerships in Myriad Genetics' portfolio of activities were shaped by the specific diseases on which the firm worked. Figure C also illustrates the simultaneous embedding of Myriad Genetics in the domains of science, finance, and commerce. We need not concern ourselves with the choice of individual partners; we are interested instead in how the pattern of affiliation consistently involves cross-domain assembly that in turn imports the practices of one realm (publishing, clinical evaluation, commercial application) into another. Mark Skolnick himself represents the emergence of a novel identity: scientist-entrepreneur. Researchers have found--in work on the U.S. in the 70s, 80s, and 90s, and England and Germany in the 90s-- that the majority of founders of new biotechnology firms come from the academy (Zucker, Darby, and Brewer, 1998; Liebeskind, 1996; Murray and Casper, 2003; add cites). Zucker et al (1998) stress that these founders are disproportionately 'star' scientists, eminent in their fields, widely cited, and with an abundant crop of students, some of whom cross over to the commercial side of science.

The movement from one realm to another generates a flow of relations and the production of material objects, some of which have wide consequence for both health and markets. But the illustration of Skolnick suggests a deeper transformation. He occupies both the CEO and department head positions simultaneously, and through membership on the founding team and senior authorship of scientific papers, bridges both realms, transferring evaluative metrics in both directions. To the extent such cross-realm reverberations are formalized - - through network topology and institutional definitions of what activities are appropriate - - novel roles and types of organization are reproduced and made concrete, setting the stage for broader changes.

Figure C: Multiple Network Mapping of Life Sciences, using Myriad Genetics as an illustration



Red links = scientific collaborations (BRCA1 paper in Science)

Green links = founding team; investors

Blue links = product development collaborations; patent co-assignment

3.) Feedback mechanisms

Within each domain, there is a crucial duality: the relational activity through which ideas, resources, objects, and news travel, on the one hand, and the more formal, categorical aspects reflected in assets, careers, organizations, and markets, on the other. Networks are less visible and often restricted to members of the relevant communities, while categories are the public addresses and thus more tangible and accessible. The logic of our analysis is that networks generate the formal classifications, which in turn sustain further amplification of the networks. For analytical convenience, we emphasize three elements that have both relational and categorical aspects: assets, biographies, and institutional classifications. Figure D sketches what we refer to as the “architecture,” and the arrows chart the “plumbing”.

Figure D: “Architecture” of Life Sciences

Duality of *category* (a zone of recognition, an address at which communication is received, a public ‘face’) and *network* (relational activity, flows, exchanges)

<i>DOMAIN</i>	<i>CATEGORY</i>	<i>NETWORK</i>
<p>SCIENCE</p> <p>Institutional classification</p> <p>Biography</p> <p>Assets</p>	<p>Discipline, org. affiliation</p> <p>Career (vita)</p> <p>Status (findings, papers, grants, patents)</p>	<p>Invisible college</p> <p>History of relations with students, co-authors, project teams.</p> <p>Citations, co-authorships</p>
<p>COMMERCE</p> <p>Institutional classification</p> <p>Biography</p> <p>Assets</p>	<p>Market structure/disease category</p> <p>Track record, based on alliance portfolio</p> <p>Experience (capability at politics, medicine, production)</p>	<p>Reputation for developing medicines of a.) high value, b.) high profit</p> <p>History of affiliations with partners/rivals on projects</p> <p>Political ties, ties to and knowledge of health care ‘system’ that can be mobilized</p>
<p>FINANCE</p> <p>Institutional classification</p> <p>Biography</p> <p>Assets</p>	<p>Investor types (VC, Corp., NIH, Foundations)</p> <p>Projects</p> <p>Capital (wealth)</p>	<p>Reputation (IPOs, ROI, research funds)</p> <p>Joint membership on Boards of Directors, review panels, VC syndicates, founding teams</p> <p>Business – scientific cross-realm linkages</p>

Academic research and training generates papers and students. The networks that connect this activity are a series of co-authorships and citations to the work of others. The ‘writing and citing’ ties are made concrete in the form of academic status, perhaps the most critical asset in the domain of science.³⁵ Status is a cumulative function of the

³⁵ The elaborate rituals of promotion and tenure, letters of reference, review committees and the like all reflect this paramount concern with assessing status.

novelty of a scientist's findings, the number of citations she receives, and the grants and patents that stem from publications. In turn, a scientist's status attracts students, colleagues, invitation, and the like, which cumulate into a history of affiliations. The formal instantiation of these relationships is a career biography, represented in a vita, which lists a string of organizational positions and publications. A career is embedded in a scientific or intellectual community. At the network level, this is an invisible college (Crane, 1972), while the formal institution is a discipline at a specific organization.

The finance domain operates in rough parallel to science, with contacts and experience generating wealth, or capital conceived broadly, that leads to invitations to join venture capital syndicates, boards of directors, or, on the public finance side, review committees. A history of successful projects builds a reputation that leads, in turn, to a position at a specific type of organization that finances biomedical research and development. The realm of commerce is less straight-forward and more complex, in part because the matching of person and organization is less reciprocal. The organizations involved in developing, testing, manufacturing, and distributing medicines are, typically, larger, more corporate, and less likely to be categorical extensions of the persons who are in their employ. Thus when we speak of ties, experience, history, and reputation, those features are attached to an organization, and represent the sum of an organization's connections. Moreover, these linkages are to a broad-based health care system, so knowledge of the appropriate levers and pressure points in that system are absolutely crucial relational assets. Recall that the core tension in this system is between saving lives and generating revenues, so reputations can accrue either for developing medicines that are of high social value or that garner large profits or both. Figure C captures the feedbacks within the three domains, but is silent with respect to access across domains. We turn now to a discussion of rules of access to flesh out cross-domain linkages.

Earlier we mentioned that the domains of science, commerce, and finance were once largely independent of another. Such a characterization applies broadly to the period 1920-1980.³⁶ Linkages across realms are freighted with tension, from fears about exploitation and failure to concerns about appropriateness and conflicting interests. In the last section, we emphasized that Florentines were perfectly capable of using kinship networks for business purposes, and subsequently rotating their allegiances to use business networks to pursue political agendas. In a similar vein, the contemporary life sciences have a deeply interconnected typology. (See Powell, White, Koput, and Owen-Smith, 2003, for a detailed depiction of this structure and its reproduction through time.) Yet not all combinations of partners from diverse domains are equally plausible or sustainable, as we illustrate in a later chapter. One critical element of the feedback process is the matching rules by which parties to an exchange determine appropriate criteria for access.

³⁶ The origins of the pharmaceutical industry in the United States in the first decades of the 20th century were characterized by intensive contact between academic researchers and industrial scientists (Swain, 197?). Similarly, the origins of the German chemical industry had similar cross-domain engagements between science and commerce (Murmann, 199?).

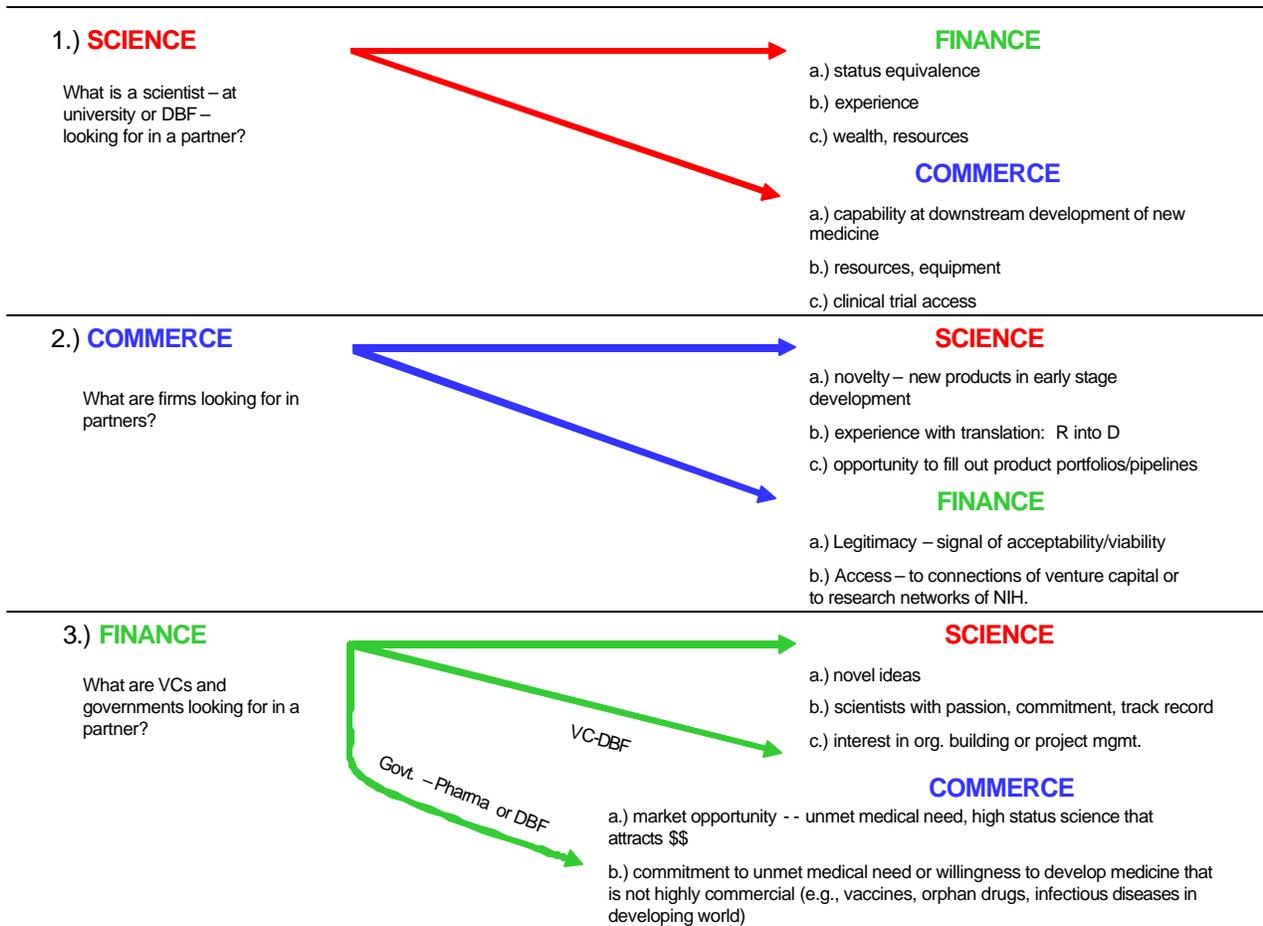
Drawing on interviews and ethnographic research, we attempt to answer the question of what the various participants are looking for in a cross-domain partner. A university scientist, either working through her technology licensing office or setting up a firm on her own, approaches the world of finance, in this case, venture capital, with an eye towards aligning with an investor who has previously worked with researchers of comparable academic status. Put crudely, when crossing realms from public science to the world of money, noted scientists do not want to appear to be “slumming.” They seek a financial partner who has both worked with people like them before and who has, based on accumulated wealth and experience, equivalent standing in the world of finance. In return, a venture capitalist looking to bankroll a researcher seeks someone who has generated novel research findings and whose academic record and affiliation gives credibility to these claims. In addition, the financier seeks assurance that this researcher has experience in running a lab group, which signals some managerial ability,³⁷ and a commitment to moving the research from the lab bench to commercial application.

Figure E sketches the access criteria for the various domains. We do not discuss this search process in detail, but the general point about status, novelty, legitimacy, and opportunity being the criteria for matching should be clear. Add to these evaluative criteria the elements of competition and reward, and the process heats up. Aspirations may rise or slide as the supply of available partners changes. Our fieldwork suggests a strong status dynamic in the scientific realm, captured nicely by a quip from a senior professor at an elite university: “In the early days (of biotech), the view seemed to be that if you won a Nobel Prize or were elected to the National Academy of Sciences, it was appropriate to cash in on your academic accomplishments; now the view seems to be if you are a full professor and haven’t won a Nobel, at least you can be a millionaire.”³⁸

The rules for access are one part of a larger set of relationships that constitute the world of the contemporary life sciences. We depict a more formal set of feedback processes in Figure F below. This exercise is not a model, rather it is a sketch that assembles various aspects of Powell and colleagues’ research program over the past decade to represent multiple network co-evolution in the life sciences. The representation does not attend to different stages in the evolution of biotechnology, rather different periods reflect concrete instances of feedback dynamics that either stymied or amplified cross-network exchanges.

³⁷ Teitelman (1989) noted that by the 1980s, academic research laboratories had become sizable and complex entities in their own right, with divergent goals. Hence, moving from the academy to the private sector no longer represented a dramatic “sea change” for experienced academic researchers.

³⁸ Owen-Smith and Powell (2001) draw on interviews with elite scientists to analyze the tensions between scientific and commercial accomplishments.

Figure E: *Matching rules*: what are the appropriate criteria for access?

We have made an attempt at explicit parallelism with medieval Florence; however, the mechanisms naturally vary. In the center of the column Figure F are various types of “actors” that populate biotech, e.g. organizations, persons, invisible colleges, boards of directors, the array of competing firms working on a particular disease, and the highly-connected set of organizations located in a position to span several domains. These actors are constituted by both relationships and categories. This image of a dual composition of flows, gifts, and network topology (on the left) and material objects and institutional categories (on the right) captures the extent to which organizations are both acted upon and have the capacity to re-make the system.

Examining feedback flows in the lower half of the diagram first, the generation of ideas, medicines, or profits enables actors to mobilize resources. In turn, these resources spawn both new organizations and/or new identities. At the same time, such resources allow for the accumulation of assets—status, experience, and wealth. These assets are the criteria for access, discussed above, and are crucial in two respects. One, status, wealth, and experience are the entry tickets into the macro-level networks, where

configuration that is formed by all these ties (the various micro-level networks we illustrated with the single case of Myriad Genetics) produces a topology, or network structure. This structure can be highly fluid, changing often as a result of new entrants or severe selection pressures, or it can be stagnant and hence retard entry. Either way, some group of actors may be located in structural positions that allow them to span domains; this location gives them clout that others lack. With this clout, they can define the appropriate institutional criteria that regulate tie formation. In previous research, we have examined the logic of preferential attachment, that is, the process by which ties are formed in biotechnology, and found that the system went from a period of rich-get-richer to one where participants tried to match one another with “appropriate” network portfolios to one where a preference for diversity was dominant (Powell et al, 2003). At the center of this shift were a small number of highly connected organizations with the ability to span multiple domains, and who used this multi-vocal ability to spot promising new entrants and sponsor them.

4.) Regime transformation

As with Florence, the critical mechanism for generating novelty in the life sciences is re-functionality. Much of the time, such transpositions occur at the interface of domains. Often, boundary-blurring activity emerges in these interstitial zones, and remains there. Put differently, many novel elements and hybrid recombinations are not sustainable. They either fail to reproduce, are actively opposed, or prove to be modest incremental editing of more traditional arrangements. Thus while the potential for innovation may be broad, the status quo routinely channels such adaptations into acceptable changes. Sometimes, however, transposition and re-combinations unlock the existing structure, and re-wire the overall system. Such changes do not necessarily entail the uprooting of incumbent actors and their replacement by challengers (a view that is standard in most explanations that rely on exogenous shocks to account for change in the first place). Elements of an elite may find new tools for holding on to their position, or forge alliances with the parties that usher in new practices, or attempt to co-opt them. In our view, regime transformations occur through the reshuffling of relations, products, and actors in response to multiple-network innovations that change the calculus by which participants evaluate their efforts.

Multiple-position combinations can be regarded as deviant, tolerable, or legitimate. Indeed, several decades ago the interface of public science and private finance would have been unthinkable. The challenge of meeting the evaluative standards of multiple, distinct domains is considerable, but such a threshold is lessened when practices in one domain satisfy the standards of those in other domains. In these rare circumstances, when cross-talk generates innovation through new models of behavior (scientist as entrepreneur), new organizational practices (proprietary firm publishing public science or public university engaging in private commerce), and new modes of financing (venture capital funds and public finance grants to start up new companies), the innovations reverberate to transform all of the participants. We stress that such cascades of innovation are unusual, but when they do take place and are reinforced by elites and

authorized by states, the potential for systemic change and the opportunity for the emergence of a host of related innovations - - be they positive or negative - - is considerable.

To sum up, “dynamic multiple networks” provide an intellectual framework for posing and operationalizing questions about emergence, catalysis, tipping or lock-in that are not routinely addressed in the social sciences. This framework, we suggest, offers the promise of integrating the joint emergence of relations, products, and actors into a coherent architecture of inter-related dynamic models. While abstract, the framework is deeply rooted in and inspired by “thick” history – in particular, by the histories of Renaissance Florence and the origins and elaboration of the commercial field of the life sciences.

The empirical payoff of this volume is the explanation of the emergence and transformation of historically specific markets - - ranging widely from the early middle ages to the present, from culture to software to banking to biotech. These diverse market transformations are viewed organizationally through the lens of network-feedback ensembles of trading, competition, careers, firms, and regimes.