This conclusion of a minimum level of substitutability for market coordination is not necessarily applicable where a certain type of transaction is commonly (frequently) employed, in which case it would tend to rely on non-specific or commonly available (i.e., highly substitutable) resources. For infrequent transactions, Williamson writes, "[i]ncentives for trading weaken" (1979: 252) with idiosyncrasy (more idiosyncratic in their resource combinations) and therefore a hierarchical governance structure appears economically superior. However, infrequently employed transactions predominantly utilizing resources commonly available in the market (cf. Foss et al. 2002) could still rely on market-based governance. But it may be the case that such transactions, to the extent they are indeed idiosyncratic but constitute primarily a new combination of readily available resources, may initially call for hierarchical governance due to the novelty (idiosyncrasy) of how the resources are configured, combined, or organized. Competitive pressures in the market would keep the transaction idiosyncratic or unique only for a limited time, so that an established hierarchical governance structure could soon disintegrate due to quickly arising cost disadvantages as other actors imitate for profit and thus compete with the original transaction. In other words, it appears that we should not see long-lasting firms formed around idiosyncratic transactions relying primarily on non-specific or fully substitutable resources, since they are easily emulated. This line of reasoning seems to directly contradict our analysis of the Coasean framework, where the firm's internal resource structure is a "mirror image" of the price mechanism's resource allocation. A Coasean firm, as its resource allocation is very similar to (or even identical with) market allocation, should not be a lasting occurrence. The obvious exception to this conclusion is where the transaction undergoes the fundamental transformation, which reintroduces asset specificity as the determinant of integration-causing transaction cost levels.

This confirms TCE's predictions and, again, strongly suggests that the firm's internal productive resource combination is structurally different from market coordination and resource allocation, not simply coordinated by a different force. Firms are therefore "not merely extensions of markets, but employ different means" (Williamson 1991a: 270)—the hierarchical mode of governing transactions means that "firms can and do exercise fiat that markets cannot" (Williamson 1995: 43; cf. Alchian and Demsetz 1972). The firm's authority relation is indeed essential to governing transactions utilizing resources of a high degree of specificity (low substitutability), since "[r]ecourse to fiat provides better assurance that adaptations […] will be performed in a coordinated way" (Williamson 1991b: 164). The market, lacking a centralized authority to coordinate production structures, is at a significant disadvantage in terms of coordinating resources with high complementarity and low substitutability due to the hold-up problem.

Comparing Transaction Cost Analyses

Whereas Williamson has argued that TCE is an "empirical success story" (1996a: 55), the discussion above suggests that the implications of asset specificity are not consistent with the Coasean view of the firm. While Coase does not subscribe to the asset specificity thesis (Coase 2006; 1988c: 12-13), our discussion above shows that the Coasean transaction cost theory of the firm does not only focus other causes of integration—but in its very assumptions disallows such structural differences between firm and market. The only reasonable conclusion is that there are (at least) two distinct transaction cost theories of the firm with different sets of assumptions. We can identify two different but equally possible reasons for this inconsistency between Coase's and Williamson's accounts of transaction cost analysis as relates to asset specificity, both of which are fully applicable in equilibrium.

First, the Coasean firm, which is supposedly adopted by Williamson, does not (at least not to Coase) rely on differences in specialization for different types of governance. Contrarily, the entrepreneur-coordinator, the only existing "specific asset" in Coase's analysis of the firm, is considered able to switch—supposedly almost instantaneously and conceivably at low cost—back and forth between firm organizing and market contracting as the relation between transaction and organizing costs change. The productive structure of the transaction is essentially the same—at least in terms of resource arrangement and allocative efficiency, whether organized through market contracts or using the authority relation(s) within the firm—and this does not appear to change as investments are made to facilitate the transaction. The transaction's resource structure within the firm differs from that of market only due to the entrepreneur's bounded rationality; the firm is therefore—if at all different—suboptimal in terms of resource allocation. Consequently, asset specificity (and therefore also the holdup problem) cannot be a significant factor in the Coasean analysis; indeed, while Coase originally considered opportunism, he "ultimately came to reject the existence of this risk as an important reason for vertical integration." In contrast, he maintains that asset specificity is "not an important factor influencing the structure of industry" and that "opportunism in connection with asset specificity did not normally pose any problem and certainly not one that would call for vertical integration" (2006: 259) since such problems can be solved contractually at sufficiently low cost.

Yet, while Coase explicitly rejects asset specificity as a cause of vertical integration, our interpretation of the Coasean view appears problematic, since there is an implicit contradiction in viewing a resource as both highly specific (complementary) for an end and yet always easily substitutable (for other resources). Such an unchanging state of things suggests that resources and productive structures are not specific to certain ends; rather, they appear much "like drops of water" (Lachmann 1947: 114) in the sense of being very highly substitutable. But this would, in turn, suggest that production structures are more likely to be simple one-stage processes rather than "a complex, multistage process unfolding through time and employing rounds of intermediate goods" (Foss and Ishikawa 2007: 755). For any complex production structure, we would expect to initially see increased complementarity and decreased substitutability.

The Williamsonian firm, in contrast, supposedly organizes internally only (or nearly so) transactions that are dependent on highly transaction-specific resources and therefore the structure of transactions within the firm must be different from transactions organized by market contracts. If a high degree of asset specificity—which, as we have identified above, implies a combination of high complementarity and low substitutability—means a transaction cannot as easily be organized through market contracting but requires integration in a firm, then this suggests that resources within firms are ostensibly always more highly specialized than resources used when transactions are coordinated using market contracts. Williamson's firm, presumably allocatively efficient but suffering productive suboptimality, should then normally be structurally distinct from production processes coordinated in the market through the price mechanism, whereas the Coasean firm is commonly similar to and strives to be structurally identical with market transactions.

It then follows that the manager of a Williamsonian hierarchy *cannot*, as Coase (1937: 392) maintains, find it "always possible to revert to the open market." Disintegrating a Williamsonian firm would imply a reversal of the fundamental transformation, where such has occurred. It should ultimately mean abandoning the integrated transaction for another, since the highly specialized resources utilized within the firm are subject to opportunistic behavior if organized through market contracting—due to their high complementarity and low substitutability—and therefore virtually impossible to coordinate in the market according to transaction cost economizing. This is, after all, the reason TCE predicts such transactions to be integrated in the first place.[12]

Second, while Coase does not primarily endeavor to identify a particular cause of transaction costs that indirectly calls for organizing transactions in firms and therefore can be measured empirically, Williamson identifies asset specificity (in terms of very low substitutability) as "the most critical dimension" of transactions and assumes that the cost (risk) of opportunistic behavior (and the maladaptation that springs from it) is what ultimately drives vertical integration. According to Williamson (1985: 30), "[p]arties engaged in a trade that is supported by nontrivial investments in transaction-specific assets are effectively operating in a bilateral trading relation with one another," which, in turn, gives reason for non-investing parties to engage in opportunistic behavior. This begs the question of how such specialized resources come to be in the first place if they are in fact

[12] Taking this analysis one step further, it seems the conceptually inferred causal direction implied in making a "choice" of governance structure for a transaction does not in effect constitute a real choice. Rather, the maximizing [equilibrium] "choice" appears already given due to the particular type of transaction, especially the resources employed therein, in line with the discriminating alignment hypothesis.

largely incompatible with (in the sense of being costly—and therefore not traded in) the market; in addition to the "fundamental transformation," in which market-traded resources are irreversibly (or reversible only at considerable cost) employed as part of a unique or transaction-specific resource, specialized resources would likely need to be *innovated* (Schumpeter [1911] 1934) in order to be sufficiently specific to induce holdups. The potential for opportunistic behavior through creating a situation of "bilateral trade" means actors, realizing this, would either not engage in such trade (or, at least, not make such investments) or vertically integrate *in order to* make the necessary investments that cause the fundamental transformation—but without risk for holdups. This seems to confirm Williamson's thesis: the risk of opportunistic behavior induces actors to vertically integrate the transaction in order to economize on maladaptation costs that may arise *ex post*. (And this further strengthens the argument that the Williamsonian firm tends to be structurally different from market transactions.)

Put differently, we find that the holdup problem through asset specificity should only exist in disequilibrium to the degree that actors fail to realize this risk *ex ante*. If this were not so, actors would choose to first vertically integrate the transaction and then make the necessary investments. Even in the case of a fundamental transformation, where perhaps many small investments create a bilateral trading relationship over time, actors would be expected to at some point identify the imminent risk for holdup as the transactional specificity of the resource significantly increases. But this assumes that actors are not only both guileful and self-interested, but knowingly so—and realize that others are as well. If there is a reasonable level of trust (cf. Williamson 1993a) between transacting parties (i.e., if we relax or do away with the behavioral assumption), the Williamsonian story does not seem to hold.

This suggests a possible problem in a pre-equilibrium setting. If transacting parties are indeed guilefully self-interested, and knowingly so, they would not choose to make specific investments unless the transaction is vertically integrated. But then their choice is not for governance structure, which is practically given for transactions requiring specific resources—it is whether to make such investments in the existing firm. The "choice," in other words, amounts to whether to carry out this type of transaction (which to be executed requires a certain type of governance structure), a decision that in itself depends on the parties first settling on the terms for integrating in a firm. This seems to raise a number of questions regarding the integration process, which however are not within the scope of this chapter.

As we saw in the previous sections, Coase and Williamson heavily yet implicitly rely on the effects of specialization in their analyses of the market and organization—but in different ways. Williamson's emphasis on asset specificity is a case in point. But whereas Williamson's firm is predicted for and created around highly specific resources, Coase's firm "need imply no specialization" (1988c: 4) and according to Coase's assumptions *cannot* be created around comparatively specific resources. Coase's point of departure in the "specialised exchange economy" implies a certain degree of specialization already implemented in the market, but it is not regarded as having a direct explanatory power for economic organization; in fact, we have seen that Coase ultimately *dismisses* the specialization argument for integration, as espoused by Robinson, Usher, and Dobb (among others), based on his theoretical assumptions. However, the existence of transaction costs depends on specialization—it seems Coase assumes a degree of complementarity while rejecting any significance of factors' substitutability in predicting vertical integration.

This suggests an interesting potential turn of events, since Williamson's transaction cost-based theory of integration, as we have seen, entails structural disparity between markets and firms *that ultimately depends on specialization*. Therefore, the implications of the Williamsonian argument—while originally based on Coase's (1937; 1960) identification of transaction costs and the firm as a means to economize on such costs—dispute Coase's assertion that specialization and the division of labor (and capital) do not entirely explain the existence (or nature) of firms. Coase arguably holds that vertical integration is brought about through a reversal of the specialization process (Coase 1988c: 10-11) In effect, Williamson's view of the internal structure of the firm is much closer to Robinson's (1931) discussion of how firms are internally organized. It implicitly adopts parts of what we may refer to as a "capital structure" approach to the nature of the firm (Bylund 2011; Lewin 2011).

Concluding Discussion

This chapter has two key contributions. The first is the identification of important theoretical differences between transaction cost analyses of the make-or-buy problem. I have argued that there are fundamental differences between how Coase and Williamson view the market and the firm, and, consequently, the interplay between markets and hierarchies. Furthermore, it seems the aforementioned differences in fundamental assumptions implicit to and underlying their approaches may ultimately be make their approaches in-commensurable. It was shown above that Coasean transaction costs are “friction” costs *in the market*, especially as relates to “discover[ing] what the relevant prices are” and “carrying out a market transaction,” whereas Williamson’s transaction costs arise due to the use of *non*-marketable resources. It was also shown that the Coasean firm in most respects is assumed to be a “mirror image” of market transactions, where the price mechanism has been replaced by a manager directing resources. Williamson’s firm, in contrast, is in equilibrium necessarily structurally different from the market because the transaction is integrated in a firm with the purpose of avoiding costs that arise due to extra-market specialization. This difference is more pervasive than Coase not “buying” the asset specificity argument—we have seen that there is reason to believe Coase and Williamson employ different and potentially contradictory assumptions. This appears to be the case in terms of behavioral assumptions as well as the internal structure of the firm as compared to the structure of similar market transactions.

Nevertheless, Coase and Williamson emphasize problems that appear complementary. Coase distinguishes between two types of coordination to explain market structure—the price mechanism and the entrepreneur—while Williamson focuses on the calculus of (conditions for) effective governance of individual transactions. Both therefore contribute important insights to the workings of the market and the existence of firms, however in different ways.

This chapter’s theoretical contribution should be of importance for researchers utilizing a transaction cost framework to study market structure and economic organization. Failing to address the adopted set of assumptions may limit the applicability of and impinge on conclusions and predictions. This conclusion could also implicate potential inaccuracies in previous research where the Coasean and Williamsonian frameworks are treated as were they the same, since underlying tensions and important differences may not have been recognized and properly dealt with. While this may compromise the accuracy of research findings in certain cases, the distinctions elaborated in this chapter offers great potential for future research to set things straight. These findings may also serve as a basis to further elaborate on the differences between and—perhaps more importantly—the consequences of the adopted assumptions in the Coasean and Williamsonian transaction cost frameworks, respectively.

The second contribution of this chapter is the distinctive perspective adopted in analyzing transaction cost theories, market structure, and the firm. In order to explore the real differences between Coase and Williamson, we identified that they implicitly yet fundamentally base their theories on the existence of resource heterogeneity and specialization: Coase assumes specialization in the market as a precondition for transaction costs while Williamson uses a similar presumption to explain integration in firms. Both of these concepts—resource heterogeneity and specialization—are alien to most mathematical models in neoclassical economics, which is the point of departure from which both Coase and Williamson developed their approaches. Through acknowledging heterogeneity, their theories provide an alternative, and potentially a more realistic, view in modern economic analysis (Coase 1998; Williamson 2000).

Interestingly, these same concepts were intensely used by earlier theorists of industrial organization—from Adam Smith to E.A.G. Robinson—who regarded them as the main causes of integration. While Coase dismisses the division of labor argument as insufficient to explain integration, his theory identifies specialization as an important quality of advanced market structure and its frictions. Williamson identifies asset specificity as the most important cause of high-transaction cost situations that drive integration, but fails to realize that, although this is an important and persuasive theoretical point, it partly contradicts Coase's theory of the firm. Williamson's TCE effectively reverses part of Coase's contribution through more explicitly adopting a core tenet of pre-Coasean theorizing on the firm and organization.

EXPLAINING FIRM EMERGENCE: SPECIALIZATION, TRANSACTION COSTS, AND THE INTEGRATION PROCESS

The Coasean Paradigm and What's Missing

If market exchange is efficient, then why are there firms? Coase's (1937) well-known answer is that integrated units, in which resources are "directed" toward their best uses, may be cheaper to coordinate due to the "cost of using the price mechanism" (1937: 390). In a competitive pure market regime, economizing on these costs would be necessary and so we should see "islands of conscious power in this ocean of unconscious co-operation like lumps of butter coagulating in a pail of buttermilk" (Robertson 1923: 85; quoted in Coase, 1937: 388). Firms should hence be expected primarily where transaction costs are relatively high.

Coase's theory, later expanded and formalized by Williamson (1985; 1991a; 2005), was developed in order to bridge a gap in the literature "between the assumption (made for some purposes) that resources are allocated by means of the price mechanism and the assumption (made for other purposes) that this allocation is dependent on the entrepreneur-co-ordinator"[13] (1937: 389). Rather than relying on the notion prevalent since Adam Smith, that specialization is more intensive in firms, Coase took another view. He assumed that the object of firms, economizing on transaction costs, is "to reproduce distribution of factors under atomistic competition within the business unit" (1988c: 4). In

[13] To Coase, the entrepreneur is "the person or persons who, in a competitive system, take the place of the price mechanism in the direction of resources" (Coase 1937: 388 fn 2).

fact, it may even be the case that the business firm is *less* specialized than the market within which it is embedded (1988c: 11).

This transaction cost theory of the firm provides a rationale for integrating coordination of resources in hierarchical business units. But while the Coasean thesis addresses the question of *why* there are firms, the question of *how* firms could emerge is conspicuously overlooked in transaction cost research. The task undertaken in this chapter follows from this overlooked aspect, and is, therefore, ultimately an extension of the Coasean argument through focusing on the "how" of why there are firms. While answering *why* there are firms does not automatically provide clues to how firms arise, answering *how* firms arise necessarily suggests sufficient rationale for entrepreneurs to establish firms. Hence, our contribution lies in adopting the same starting point and using the same contrast (price mechanism vs. entrepreneur) while asking this slightly different question with broader implications. In addition, I contrast the Coasean view of the firm as a reflection of market allocation of resources with the view that preceded the Coasean legacy, i.e. the view that a firm is more specialized than the market (cf. Smith [1776] 1976: 8-9), in order to further strengthen the argument.

More specifically, I construct a model for firm emergence starting from the Coasean conception of "atomistic competition" in a specialized exchange market. Following Coase, the model assumes that the entrepreneur is the force that establishes firms and I rely on theories of specialization to implement productivity effects of intensified division of labor within the firm. I also consider the effects of transaction costs on market coordination as well as the process (and result) of integrating production processes under an entrepreneur. The model particularly considers necessary and sufficient conditions for the entrepreneur to successfully bring about an integrated production process with a hierarchical governance structure.

The chapter proceeds as follows: in the next section, I summarize the specialization and transaction cost arguments and how they relate to each other. I then discuss the basic assumptions in the “atomistically competitive” model and attempt to explain firm emergence using Coase’s perception of transaction costs. Thereafter, I show how specialization applies to the integration process and discuss the implications of specializing and the effects of co-specialization. I also elaborate on the role of the entrepreneur and analyze the effects of transaction costs on the specialization-based integration process. Finally, I summarize the implications of the model and discuss opportunities for future research.

Specialization and Transaction Costs

Most economic theorists of the firm prior to Coase (1937) subscribed to a division-of-labor view of what is a firm. Following Adam Smith’s discussion on the division of labor in the pin factory, they assumed that “work may really be divided into a much greater number of parts” (Smith [1776] 1976: 8) in the big “manufactures” (factories) as compared to the smaller ones and, especially, the market. In fact, it was even claimed that the “typical form” of “[t]hat co-operation which is based on division of labor” takes place in the “manufacture” (Marx [1867] 1906: 368). Integrated firms can therefore benefit from more efficient production through utilizing more intensive specialization (Robinson 1931), a thesis that Lawrence and Lorsch (1967: , esp. ch. 2) established empirically when looking at firm performance from the point of view of successful differentiation through integration.

Specialization can be usefully and generally defined as developing specificity in use or utilization. The concept is used in several types of analysis and on different levels, which unfortunately contributes to the concept's ambiguity. For instance, studies in international trade look at specialization among and between countries, such as inter-country vertical-specialization-based trade (Hummels, Rapoport and Yi 1998). There may also be intra-industry specialization (Krugman 1981), such as corporate specialization through selloffs and takeovers (Bhagat, Shleifer and Vishny 1990). Most uses are on aggregate levels, however, and hence assume at their points of departure some sort of grouping or integration. As the purpose here is to study the emergence of the lowest level of integration (firms), these uses are inapplicable. Instead, specialization is used on the most basic level—a single resource. Specialization thus entails how it may be used; a more specialized resource is more adapted to one or several certain types of use or tasks than a resource less specialized.

While not necessarily irreversible, specialized resources often tend to become increasingly efficient in certain specific uses at the expense of efficiency in other uses (Lachmann [1956] 1978; Lewin 2011). Specialization in human resources is commonly discussed in terms of the "division of labor," but specialization occurs in capital too. For instance, machinery is often developed to perform certain tasks and therefore intended for specific uses—perhaps to replace labor performing those tasks. Any machine thusly specialized often cannot, as a consequence, as efficiently be used as a resource to supply other or additional services.

As an example, a common train car can due to its simple design (perhaps with a flat surface or with simple walls and roof) be used for transporting a wide variety of goods. The car is unspecialized in the sense that it can be used for transporting logs, automobiles, dishwashers, hay, live animals, and so on. But it is quite easy to see that a train car intended specifically for the transportation of live animals (perhaps with certain-size cages with ventilation and forage, etc.) may be a much better solution when doing so. At the same time, a train car intended to transport live animals could possibly be used to transport logs or automobiles, but would likely not be a very efficient choice. Indeed, the greater specificity in use that we have in the train car developed for transporting live animals suggests that it may be more costly in alternative uses, e.g. transporting automobiles. In general, efficiency (or suitability) increases with resource specificity—it is more intensively specialized—but the resource usually also becomes more costly in alternate uses (as compared to both other as intensively and less intensively specialized—i.e., more generally usable—resources).

As shown in this example, specialization implies heterogeneity,[14] and increased specificity or specialization should intensify a resource's *complementarity* through increasing its interdependent connectivity with or even dependence on other specialized resources. It is also expected that this results in decreased *substitutability*, i.e., the degree to which amply compatible substitutes exist for procurement in the market (Lachmann [1947] 1977; [1956] 1978).

[14] It should be noted that it is theoretically possible, however unlikely, that specialization does not lead to heterogeneity. For this to be the case, it is necessary for all specialization endeavors to take place (1) at the same time, (2) in the same manner and with the same result, and (2) that all similar resources are specialized.

The reason the firm was believed to utilize higher specialization intensity and therefore a more intensive or far-reaching division of labor is explained by the relative closeness of factors within the firm. The division of labor, as Smith ([1776] 1976: 21-25) identified, is limited by the extent of the market, i.e. the factors' ability to "act and react upon one another" (Durkheim [1892] 1933: 257). Coordination of factors in an integrated firm under the guidance of an entrepreneur increases their relative "closeness" while allowing for increased productivity through the structured alignment of incentives, active co-specialization, and the standardization and adoption of advances in communication and transportation.

Coase implicitly subscribes to the "closeness" argument and acknowledges that "[i]nventions which tend to bring factors of production nearer together, by lessening spatial distribution, tend to increase the size of the firm" since they "reduce the cost of organising spatially" (1937: 397). In fact, his views were greatly influenced by contemporary division-of-labor theorists of the firm (Jacobsen 2008), but he dismissed their suggested conclusion that the function of firms in the market is to provide a framework in which productivity gains of a more intensive division of labor can be exploited. To Coase, the firm cannot outdo the market in terms of resource allocation, as the division-of-labor argument suggests (see e.g., Robinson 1931; 1934). Rather, while efficient in terms of resource allocation, the market is subject to costs of "carry[ing] out a market transaction" (Coase 1960: 15) that the firm ultimately can avoid through the supersession of the price mechanism. It follows that the firm would ideally (and should therefore strive to) "reproduce distribution of factors under atomistic competition within the business unit" (1988c: 4). Hence, the *raison d'être* of the firm here lies in the entrepreneur's ability to successfully reproduce the market's resource allocation while "carry[ing] out his function at less cost, taking into account the fact that he may get factors of production at a lower price than the market transactions which he supersedes, because it is always possible to revert to the open market if he fails to do this" (1937: 392).

The Basic Model: Atomistic Competition

Our point of departure is a market without firms and employment relations where "every transaction involving the use of another's labour, materials or money [is] the subject of a market transaction" (Coase 1988c: 4). It is similar to Williamson's theoretical conjecture that "in the beginning there were markets" and that "[o]nly as market-mediated contracts break down are the transactions in question removed from markets and organized internally" (1985: 87). As does Coase, we assume the market is a specialized exchange economy that may include highly specialized and roundabout (i.e., including several stages and/or tasks) production processes. Considering the complex nature of roundabout production processes in the "specialised exchange economy" (Coase 1937: 390), the market situation would be characterized by approximately equal factor specialization as all actors must provide market-compatible goods and services. The competitive nature of the "atomistically competitive" market implies that any variations would either be profitable and therefore soon emulated, or generate losses and therefore soon be avoided; under optimal conditions, profit maximization entails maximization of market size. This suggests a situation where production tasks are standardized so that they are universally compatible with outputs of preceding and inputs of subsequent production stages, and there are no severe incompatibilities due to differing degrees of specialization.

In other words, while there is factor specialization and heterogeneity in the market, engaging in further specializing is circumscribed by cross-factor complementarity. Individual factors can only assume already existing positions in the prevailing production structure, but cannot intensify their specialization to the extent that this results in incompatibility with existing factors. For specialization intensification to be possible (by which is understood the *division* of a production stage or task into several tasks), an existing task must be replaced in its entirety for the factors not to be incompatible. The independent development of more intensively specialized factors to be used in complex, roundabout production processes is possible only to the extent this preserves existing complementarity. This should primarily be possible only under very limited further specialization or the simultaneous development of specialized, serial processes. We should therefore see a relatively stable "level" of specialization among factors (as they cannot change unless as a coordinated effort), and factor specificities should always be approximately commensurable and their individual sets of available alternative uses roughly the same.

For the sake of simplicity, we assume that factors are evenly distributed across the market (the extent of the market is similar to all actors) and the degree of resource heterogeneity induces trade but does not cause factors to suffer limitations due to extensive incompatibilities. This suggests a form of market equilibrium that is relatively stable over time. Any single-handedly sought specialization potentially increases productivity for the individual factor but necessarily limits the extent of its market; innovation is therefore viable only to the degree it can be fully implemented by a single factor and there remains sufficient market demand for its output after its implementation. Single-handed, uncoordinated specializing from within a highly complementary production structure creates incompatibility that suggests unmarketability and failure due to incompleteness. For instance, specializing to produce a new kind of guitar string fails the market test unless it fits with existing guitars or new, compatible guitars are also being produced, just like a cab driver can specialize in driving around corners but will not find a market for his service unless it can be combined with other services (driving straight forward, parking, etc.) so that they jointly supplant existing ones. Thus, this specialization equilibrium is self-enforcing and appears unchanging in terms of its division of labor unless such specializing efforts can be coordinated.

To reformulate in formalized notation, we have that specialization intensity $s_i[0, \infty]$ at time 0 in any individual factor i must correspond to the market's specialization S_m so that $s_i \approx S_m$. The market for i's output includes a set of potential buyers $m_i = \{1..\infty\}$ where at a minimum the market size $m = 1$ and, under market structures similar to perfect competition, potentially $m \rightarrow \infty$. Under atomistic competition, m is expected to dramatically decrease as i specializes, since compatibility with other factors necessarily declines (as above, assuming no extensive co-specialization), possibly at an increasing rate. Consequently, $m \rightarrow 0$ as s_i diverges from S_m so that $s_i = (S_m + d_i)$, where d_i is the additional specialization by i. The market size would here in effect be progressively decreasing in d_i, and at great magnitudes of d_i we would expect $m \rightarrow 0$ so that $m_i \approx 0$ (see figure 3 below).

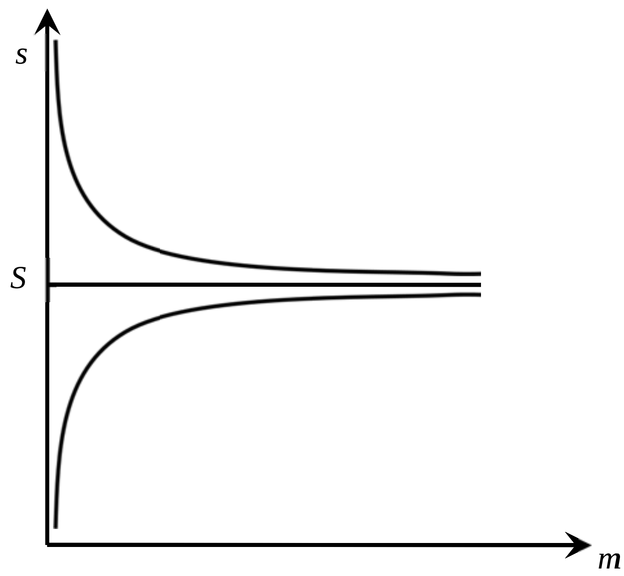

Figure 3. *The relationship between factors' degree of specialization (s) and their potential market (m) in terms of numbers of buyers and/or sellers*

From factor i's point of view, profits would be maximized when producing and selling output $q(x)$, a function of the quantity of input x, where the factor's relative specialization $s_i / S_m = r_i \approx 1$. We disregard heterogeneity in inputs since we are primarily interested in the effect of i's specialization on market compatibility, and therefore the factor's production function can be represented in simplified Cobb-Douglas functional form

$$\max q = x^{r_i} \qquad \text{s. t.} \quad m(d_i) \geq 1 \tag{1}$$

The factor's relative specialization r_i here signifies the output elasticity for the input x, i.e. the responsiveness (productivity due to relative specialization intensity) of output to changes in input, and we accordingly expect the factor i to experience increasing returns to scale where more intensively specialized than the market, i.e. where $s_i > S_m$ and so d_i is positive; greater specialization therefore implies increased productivity (Young 1928). Also, output quantity increases with r_i, since $\partial q / \partial r_i > 0$ and, as expected, factors engaging in under-specialization ($r_i < 1$ and $d_i < 0$) suffer from relative inefficiencies. The production function is constrained by compatibility criterion m, which represents the limitation of a factor's market size and is a function of the factor's relative over-specialization $d_i = (s_i - S_m)$. Since the factor suffers productive constraints where there is lacking compatibility with complementary factors, the market constraint $m(d_i)$ decreases progressively with changes in $|d_i|$ with a global maximum at specialization intensity S_m (where $m(0) \rightarrow \infty$).

In other words, as the factor's relative specialization intensity increases so does relative output productivity due to increasing returns to scale. These outputs may also become increasingly incompatible with input demands of potential buyers, which has a strictly limiting effect on the marketability of outputs; the factor can no longer gain from trade and therefore fails the market test. Accordingly, the complementarity and interdependence of productive factors constitute a self-enforcing mechanism for the already established market specialization intensity. The atomistically competitive market, as imagined by Coase, is indeed both stable and efficient.

Transaction Costs

Following Coase's example, we add "marketing costs" (transaction costs) to the model. These costs primarily relate to "discovering what the relevant prices are" and "negotiating and concluding a separate contract for each exchange transaction which takes place on a market" (Coase 1937: 390-391). Of course, if there is a cost to contracting and "[a] factor of production (or the owner thereof) does not have to make a series of contracts with the factors with whom he is co-operating within the firm" (Coase 1937: 391), then it follows that intra-firm transactions are less costly than market transactions. Coase's conclusion is in this sense tautological.

In terms of the emergence of (rather than rationale for) firms, the transaction cost construct suggests that repeated, standardized exchange and long-term contractual relationships are inherently less costly, at least from a transaction cost perspective, than one-off exchanges or short-term contractual relationships. Self-employed agents, recognizing this fact, should therefore tend to find trading partners with whom they establish longer-term relationships to avoid costs of repeatedly setting up contracts with similar terms. With established market prices and standardized specialization, it is conceivable that factors would exploit such opportunities to the extent admitted by their risk aversion with regard to changing future market prices. We might therefore expect factors to engage in long-term vertical contracting in order to avoid transaction costs and market uncertainty in terms of available inputs and market for outputs.

Consider a production process comprising at least two separate, serially interdependent stages under the current market structure as in Figure 4 below. Two self-employed labor workers j_1 and j_2, with j_1 producing the "upstream" half and j_2 the "downstream" half of their joint production process, negotiate terms for exchange: j_2 buys inputs that are produced by j_1. Both are negatively affected by costs of negotiating the terms of each individual transaction. As j_2 is expected to continue producing using the type of output produced by j_1, they are both better off setting up the contract to allow repetitive exchanges at already agreed-on terms, since both would save the cost of contracting. Likewise, j_1 is better off doing the same with someone producing j_1's inputs and j_2 is better off contracting with someone using j_2's outputs as inputs, and so on throughout the productive chain. This confirms Coase's thesis that it is "cheaper" to avoid [spot] market transactions, and we see that transaction costs therefore seem to provide incentives for factors (tasks) in serial production processes to engage in long-term contracting.

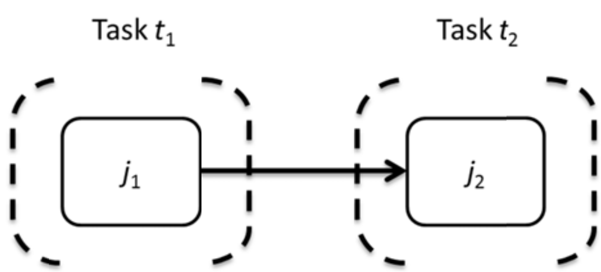

Figure 4. *Market organized production process consisting of two tasks carried out by two factors*

The factors may engage in limited co-specialization (such as co-location to increase "closeness") in order to facilitate delivery of intermediate goods (i.e., j_1's output), but would not engage in further specialization. Such further specialization is not possible since specialization entails that more narrowly defined tasks are performed, which suggests incompleteness in the factors' joint production. Any specialization must be done as changes to the factors' individual tasks, which in turn must be either in the form of changes in their respective procedures (which could easily be done by the factors independently) or shifts in responsibility (which must increase one factor's responsibility while decreasing the other's, thereby offering no potential for productivity gains). Even assuming extensive co-specialization, the factors lack a coordinator around which to establish a firm; they engage in any necessary coordination efforts as equal parties to their long-term contract.

Long-term contracting relationships do not, however, constitute an integrated firm, but what Williamson (1991a) refers to as a "hybrid" governance structure. Similarly, Coase's firm (as well as Williamsonian "hierarchy") requires further integration since it "consists of the system of relationships which comes into existence when the direction of resources is dependent on an entrepreneur" (Coase 1937: 393). Long-term contracting does not necessitate entrepreneurial direction, which means we have yet to explain the progression from long-term contracting to *integrating* a production process and subjecting it to entrepreneurial direction. Relying on Coase (1937; with support from Coase 1960; 1988a; 1988b; 1988c), we are not able to construct an argument that fully explains this process of integration from a market state of atomistic competition to full-scale integrated firms. This may be solved by adding Williamson's explicit behavioral assumption of "bounded rationality," where we assume agents to be "intendedly rational, but only limitedly so" (Simon [1947] 1961: xxiv), which "relegates all forms of comprehensive contracting (with and without private information) to the infeasible set" (Williamson 1988: 68). This assumption suggests that self-interested but risk averse actors may prudently refrain from engaging in longer than medium-term contracting due to the risk of opportunistic behavior and uncertainty regarding future prices (Williamson 1993b). Following Williamson, we may find probable Alchian and Demsetz's (1972) thesis that the contracted workers decide to hire a manager to monitor their behavior and direct resources to maximize profits.

This manager may then decide to expand horizontally through employing more factors for each production stage, thereby establishing redundancy. But as we, with Coase, assume "no specialization within the business unit" (Coase 1988c: 4), we can at best expect constant returns to scale through integration. (There should be no incentive for self-employed actors to contract with others supplying the same product or service except for the purpose of colluding, which would likely be impossible under atomistic competition due to the sheer number of actors providing similar services.) Coase further argues that the limit to the firm's size is decided by the marginal transaction, since there are "decreasing returns to the entrepreneur function" (implicit bounded rationality) and that, at some point, "the entrepreneur fails to place the factors of production in the uses where their value is greatest" (1937: 394-395). The manager must be sufficiently anticipative in directing resources to maintain close to market efficiency while saving enough on avoiding transaction costs to cover the loss in efficiency, costs of organizing, and his own remuneration. This suggests the probable outcome of horizontal expansion through employing more factors is in effect *decreasing* returns to scale, which should have a strictly limiting effect on the size of the firm.

The lack of specialization relative to the market is an obvious limit to the size of the Coasean firm, especially as large organizational units would need to take advantage of division of management (Robinson 1931; 1934)—a form of specialization and intra-firm structure disallowed by the Coasean framework (cf. Coase 1988c: 11). Organizing production in a federated hierarchical structure entails some form of specialization—at a minimum in the managerial coordination of the units, a function unmentioned in Coase's theory of the firm. Without internal specialization and the consequent lack of relative efficiency, the theory of the Coasean firm embodies a tension between two tendencies. On the one hand, the larger the firm the greater the savings on transaction costs since there is market incentive for (contract-based) *complete* vertical integration to avoid transaction costs throughout a production process. But this seems to provide an incentive for expanding already existing firms, while not necessarily offer an argument for establishing a firm. On the other hand, the firm faces a strict limitation in and diminishing returns to management as well as relative inefficiency due to the lack of internal specialization, which seems to say "the smaller the better." It suggests that firms should never expand (include more transactions) and that a firm would not experience economies of scale.

Specialization

As we saw above, it is not feasible for a single actor to specialize beyond what is compatible with the prevailing market structure. But factors may jointly specialize to each other in a coordinated manner through co-specialization (serial modularity with cross-modular interdependence). This implies increased division of labor between the cooperating factors and consequently the division of a task into simpler, interrelated and interdependent tasks. It suggests that the factors willingly establish a mutual dependence on one another as well as the established relation, creating an exclusive chain of unique, interdependent, and complementary factors constituting a combined productive capability that potentially offers the whole chain competitive advantage.

Imagine that a single, generic factor may be used to produce a good *a*. The same good could more productively be produced by several factors that are specialized to specific parts of the production process. Engaging those factors in specialization would effectively break up the production process into more narrowly defined (more specialized) tasks that are interconnected and interdependent. The contribution of each of these factors, therefore, is dependent on the contribution of the other factors as the outcome of such specializing is not (yet) saleable in the market. Until other factors follow suit and specialize to the same intensity, there is no market for inputs and/or outputs to support the individual factors in the specialized production process—the factors engaging in extra-market (co-)specialization develop a symbiotic relationship of interdependence.

The effect of co-specialization is hence a dramatic reduction to the market size (m) for *all* co-specialized factors j that work to supplant a task t. As their specialization intensity s_j is higher than the atomistic market level S_m, this subjects the factors to incompatibilities in inputs and/or outputs while effectuating a fixed market size. Co-specialization in a process where $s_j >> S_m$ for all j, and therefore $d_j >> 0$, necessitates that $m_j > 0$ and that $m_j < \sum j$ for all co-specialized factors. We also have that $m_j \rightarrow 1$ in a serial production process due to the exclusivity of the relation(s) and the wide-ranging incompatibilities with market-traded factors resulting from extensive (co-)specialization.[15]

To illustrate this, consider extensive serial co-specialization of j_1 and j_2. To j_1, specializing in the "upstream" half of the production process, the effect is a productivity increase with increasing returns to scale while the compatibility constraint forces the market constraint m to zero. Without j_2, who uses j_1's output as input, there would be no factors compatibly specialized to find use for j_1's output. To j_2, the compatibility con-

[15] It should be noted that while intensified specialization (and therefore splitting of tasks in a production process) may imply modularity, initial co-specialization does not necessarily entail specified or standardized interfaces between intermediate goods/producers. In other words, increased specialization can but does not necessarily imply decomposability (Baldwin 2008), but intensified specialization can effectuate standardized modularity that in itself may support evolution and development of improved products (Baldwin and Clark 2000; cf. Langlois 2002).

straint applies similarly but to its *inputs*, which are provided only by j_1. (We assume j_1 and j_2 aim to supplant an existing task in the market, and thus that inputs used by j_1 remain the same and j_2's outputs remain fully compatible with the existing market.) Consequently, the factors establish a bilateral trading relationship. Thus co-specialization necessitates interdependence, and therefore a risk to the factors involved, but it also constitutes a real competitive advantage as compared to the external market where successful (Barney 1991; 1995; Dierickx and Cool 1988; Ethiraj et al. 2005; Peteraf 1993; Peteraf and Barney 2003; Porter 1985).

Consequently, the individual factors in the interdependent chain effectively reject market salability for intermediate products in the specialized process, which suggests a lack of market benchmarks for assurance of efficiency: the production functions of both j_1 and j_2 are unique. The co-specialized process suffers from incompatibilities with external factors and so cannot benefit from the price mechanism or competitive discovery (Hayek 1978), which constitutes a high-powered incentive to uphold a high-density structure of co-specialization. This seems to suggests that the production process should not suffer from cognitive dissonance (cf. Brusoni 2005) since the factors in the high-density structure are highly interdependent through (possibly on-going) co-specialization. It may also be the case that the specific (and opaque) resources limit the availability of external financing, since their comparatively high specificity entails financial costs that may be restricting from a financial point of view (Vicente-Lorente 2001).

In order to bring this increased productivity to fruition and reap profits from the competitive advantage, ultimate inputs used in and final products produced by the process must be compatible with (already traded in) the market. The co-specialized process depends on trade, but its (unique) combination of co-specialized factors is more efficient than processes established through market exchange at the market specialization level S_m. Also, the co-specialized process would appear a "black box" to the market since the cross-factor extra-market specialization is incompatible with the market and hence implicitly separated and thus effectively encapsulated through the lack of market exchange involving similar factors. The intensively specialized factors in the new structure are neither priced nor traded by market means.

Consider a linear process[16] producing good *a*, which in the prevailing market specialization S_m uses three distinct and temporally dependent tasks t_i. Assume that three factors i_4, i_5, and i_6 co-specialize to jointly supplant task t_2 with a set of more narrowly defined tasks. Through extensive specialization and co-specialization, $i_{4\text{-}6}$ provide a profitable service to the market through increased productivity in the intermediate step t_2 through dividing it into the distinct sub tasks t_{21}, t_{22}, and t_{23} (see Figure 5). What previously was a straightforward chain of three specific production tasks, executed at approximately specialization S_m and coordinated through market prices, is now more roundabout through the increased and encapsulated specialization of the intermediate step. The efficient process now comprises t_1-[t_{21}-t_{22}-t_{23}]-t_3 where the intermediate tasks t_{21}-t_{22}-t_{23} are more highly specialized (more narrowly defined), and the input for t_{21} (the output of t_1) as well as the output of t_{23} (the input of t_3) are traded (or tradable) in the market whereas intermediate products are not.

[16] This is a very simplified production model. The real market generally sees much more complex production processes, both dynamic and non-linear (Istvan 1992).

In order to successfully compete with and supplant t_2 through exploiting the productive capability of [t_{21}-t_{22}-t_{23}], the co-specialized sub-process must be compatible with the remaining productive structure in the market (i.e., t_1 and t_3) or, alternatively, rely on substitute inputs that do not require new production structures (they should already be available in the market). Incompatibility with either t_1 or t_3 suggests failure through disconnecting the encapsulated sub-process from the market.

Clearly, the productivity of [t_{21}-t_{22}-t_{23}] must prove at no lower than that of t_2 in the competitive market in order to prevail. We would therefore expect only production processes of higher degrees of productivity through specialization to survive over time.

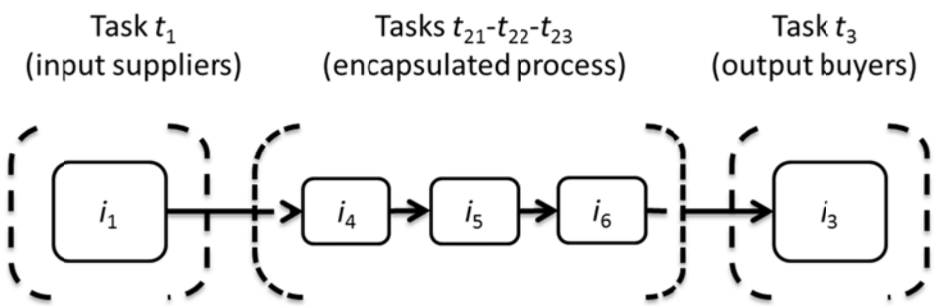

Figure 5. *The encapsulated co-specialized process in its market context (input suppliers and output buyers)*

The outputs of tasks t_{21} and t_{22} are of limited salability (demand consists exclusively of i_5 for t_{22} and i_6 for t_{23}), just like the inputs for t_{22} and t_{23} exist in effectively zero supply in the external market, since markets are yet to be established for these products or services (Stigler 1951). The success of co-specialized factors i_4, i_5, and i_6 depends on executing *the whole chain* [t_{21}-t_{22}-t_{23}]; any fraction thereof is unsalable and would fail the market test. Moreover, real profits of the co-specialized process are earned for the completed full chain of tasks only, i.e. when the final product of the complete sub-process [t_{21}-t_{22}-t_{23}] is sold as input to task t_3, since the intermediate input/output combinations lack adequate market prices (Mises [1936] 1951). Profit maximization can therefore not be done on the task level since true market prices cannot be estimated for the individual task, and thus optimization attempts must be coordinated for the full chain. The allocation of profits as generated by the individual tasks and, consequently, their respective profit shares, is consequently subject to the factors' collective decision-making (cf. Alchian and Demsetz 1972; Jensen and Meckling 1976).

The limited (if any) salability of intermediate products is the initial and necessary result of extra-market specialization despite the implied simplification through division of t_2 into the more narrowly defined (and presumably simpler) tasks [t_{21}-t_{22}-t_{23}]. In order to engage in such specialization, each of the factors faces a constrained maximization problem in which the value of the productivity increase through specialization is subject to the "cost" of interdependence. The latter seems to offer some support to Williamson's conception of transaction costs as primarily maladaptation costs due to opportunistic behavior in bilateral trading situations (Klein 2010; Williamson 1985; 1993b; 1996c). Interestingly, while the magnitude of such costs should be important in any factor's decision making, transaction costs do not appear to drive or cause integration but appear as a consequence of specialization.

While the relative profitability of a certain specialized production process may diminish with competitive pressure, the benefit of specialization-caused efficiency persists over time. In contrast, the interdependence restriction is limiting (in terms of the potentiality for trade) to these tasks only before the market—through competitive pressure in pursuit of profit—adjusts to and adopts the more roundabout and efficient structure of production. Other factors may imitate or emulate to get a share of profits, which opens up for competition among performers of the tasks t_{21}, t_{22}, and t_{23}. This subjects the structure to price mechanism allocation through generating competitive markets for each of the individual tasks. This provides factors involved in the initial specialization with incentives to closely co-locate in order to create high-density "islands" of specialization aiming to maximize benefits; doing so would also seem to reduce the potential for or magnitude of monitoring and transaction costs, and minimizes transparency (imitability) and so could help stave off competition.

Transaction Costs and Co-Specialized Structures

Highly co-specialized production processes cannot be passively adopted. It is not sufficient for individual factors to identify potential opportunities and then act on their perceived relative transaction costs. Specializing is costly to the factor as doing so limits its salability (available market) and thereby makes price discovery more costly; it is implausible that factors would assume such costs unless salability is maintained and gains from specializing exceed any such costs. Specializing *beyond* the prevailing (self-enforcing) market level S_m is not viable, so there can be no transaction costs inducing factors to specialize far beyond what already exists in the market.[17] Rather, transaction cost influence in decisions to specialize should *curb* specialization as factors attempting to specialize

[17] This is a matter of viability and feasibility—not transaction cost magnitude. The division of a market-traded production process into new tasks implies there can be no transactions involving these tasks and therefore no transaction costs. Transaction cost reasoning assumes some level of tradability or the cost would necessarily be infinity.

further impose strictly limited (or even non-existent) markets on themselves. The benefits of specialization therefore come at a high cost.

Define the market's specialization intensity as an interval around S_m (which is more realistic than above), such that there are upper and lower bounds for what degrees are feasible and inter-compatible; the specialization feasibility assumption is hence relaxed. We consider feasible any chosen specialization within the boundaries $S_m \pm f_m$, where f_m signifies maximum viable variability around the mean in degree of specialization, so the market for factor i is sufficiently large to economically justify market specializing where $d_i \leq f_m$. Hence, supply of inputs and demand for outputs for this individual factor is at least at the level of m_i*, the market size necessary for factor i to not make long-term losses, and therefore $m_i \geq m_i^* > 0$ within $S_m \pm f_m$.

As factor i specializes beyond S_m, m_i decreases but will not reach a level below that of m_i* while still within the feasibility interval (while $s_i \leq (S_m + f_m)$). This suggests that Coasean transaction costs induce individual factors to avoid specialization efforts; transaction costs (in and by themselves) thus explain a general trend *away* from the upper bound of the feasibility interval and toward S_m, as proximity to the market specialization mean maximizes compatibility and therefore minimizes marketing costs. A decrease in m_i implies higher transaction costs due to the limited available market, which means a factor should have a smaller set of potential input suppliers as well as fewer alternative outlets for its products. Therefore, transaction costs should increase as m_i decreases and be lowest at $s_i = S_m$ where $m_i = m_{max}$.

Only where gains from specialization exceed transaction costs would individual factors conceivably have incentive to specialize, yet such efforts would only take place within the feasibility interval as independent specialization beyond this boundary is productively impossible. Furthermore, it cannot be conclusively shown whether the gains from specialization exceed transaction costs within the feasibility interval, and it cannot be established whether individual factors would choose to specialize. Co-specialization to replace an existing task through dividing it into several more narrowly defined tasks necessarily falls outside of the feasibility interval, since there is no reason competing factors would not exploit such an opportunity if compatibility can be maintained (as is the case within the interval).

Similarly, the Williamsonian framework (1975; 1985; 1996c) predicts vertical integration as specialization $s_i > (S_m + f_m)$, since it causes considerable dependence on transaction-specific investments that highly increases the risk of *ex post* opportunism (Williamson 1991a). Vertical integration is the optimal governance choice where these costs appear sufficiently high, which explains equilibrium outcomes. But it does not explain how or why individual factors would specialize beyond the upper bound for market compatibility (where we may expect dependence on specific assets), since opportunism poses no risk in the market setting. To actors, co-specializing entails interdependence (since it sees no external markets) and does not imply gains from reneging on co-specialization agreements; without individual investment in assets specific to the co-specialized process, opportunistic behavior would only dissolve the agreement and force all co-specializing factors to the comparatively less productive market setting. This suggests that factors generally lack incentive to engage in individual specialization (or invest in specific assets) beyond the point where integration becomes the optimal choice; rather than a necessary outcome of specialization, integration appears a prerequisite or possibly *a means to* specialize.

Consequently, transaction cost economizing seems to provide a rationale for vertical integration *ex post facto*, but it offers no incentive for integrating under specialization unless factors are already in a suboptimal situation. Considering choices by individual factors, transaction costs do not explain the process *leading to* integration since transaction costs primarily provide an incentive to not extensively deviate from the atomistically competitive mean; in this sense, transaction costs fail to account for firm *emergence*. Thus, the overall empirical market trend toward continuously intensified division of labor and capital, with more complex production structures and increased gains from trade, remains chiefly unexplained. Hence, the market should provide something that counteracts the effect of transaction costs—and surpasses it in magnitude.

The Role of the Entrepreneur

We have seen how co-specialization creates unique capabilities within effectively "encapsulated" units and is critical to understand the causes and grounds for the integration process in the market. Individual factor specialization where $d_i > f_m$ will make any factor i incompatible with other factors and market trade, and is therefore not a viable course of action. On the other hand, co-specialization requires both extensive coordination of factor inter-specialization (itself a reason to assume excessive transaction costs) and, unless factors individually and spontaneously specialize to form a coordinated production process, pecuniary incentives for factors to give up their market compatibility. This further strengthens the thesis that transaction costs, while important in a more complex market already with numerous firms, play little role in the emergence of firms (Jacobides and Winter 2005).

While pairs of actors may provide sufficient joint coordination to establish a novel (more specialized) production structure, more advanced structures may require formal coordination. While Coase (1937) assigns this role to the "entrepreneur-coordinator" (acting manager), it is essentially a passive function existing only within firms—the Coasean manager coordinates already specialized factors. This role is inept to establish novel production structures; "[m]anagement proper," writes Coase about this entrepreneur's role (1937: 405, p. 405), "merely reacts to price changes, rearranging the factors of production under its control." It is an administrative function that supervises and coordinates the production process, oversees its boundaries and responds to market prices, and rearranges resources to maximize output (Mintzberg 1979: 18-19, 24-26; cf. Farrell 1957).

As we saw above, Coase's theory of the firm lacks an explanation for the process of establishing firms (emergence). The manager is primarily an executer of business decisions whose task is "to adjust—within the limited scope left to his discretion—the operation of his section to the state of the market" (Mises [1949] 1998: 302). As such, the manager directs resources within the existing firm—but does not imagine or create it. Coase's theory of the firm contrasts firm organizing with market coordination but lacks, as was elaborated upon above, a cause of firm emergence to provide for the process of moving from one to the other. The initiative and original coordination of factors *specializing* to achieve a coherent and efficient joint production structure lies with this omitted role, which we might call the imaginative entrepreneur. Relative the entrepreneur, the role of a manager is "to relieve the entrepreneur of involvement in too much detail" (Mises [1949] 1998: 301).

The entrepreneur must rely on his judgment (Knight [1921] 1985), since the structure about to be produced is imagined but does not yet exist (Schumpeter [1911] 1934). He must also bear the uncertainty of the enterprise. The entrepreneur discovers and creates the profit opportunity (Wood and McKinley 2010), but depends on factor specialization and capability creation through factor co-specialization: the firm is the entrepreneur's means to bring about and guide this process (Witt 2007; Bylund 2011). It is consequently not a choice of governance or means of coordination in the strict sense; as we have seen above, integration is rather a *prerequisite* for instituting extensive division of labor and capital, and facilitating factor co-specialization in accordance with the entrepreneurial vision of a new and more productive process of production. The choice is to pursue this novel production structure through specialization, which requires integration.

To elucidate the role of the entrepreneur in firm emergence and distinguish this function from that of the manager or worker, consider a market that is characterized by Coasean atomistic competition under which there is no integration. Also, assume that all actors are sufficiently non-entrepreneurial so that they cannot imagine (and realize) new structures of production and thus cannot act as entrepreneurs to establish "islands" of super-utilized specialization. Some or all are endowed with limited entrepreneurial ability such that they can take advantage of specialization opportunities within the compatibility interval $S_m \pm f_m$, but the existing market structure offers no incentives to specialize further. Hence, $d_i \leq f_m$ for all i.

We expect factors to specialize close to or above S_m up to the point of $S_m + f_m$, as this implies productivity gains with maintained market compatibility, but we do not expect actors to *en masse* engage in loss-generating sub-optimal productivity at $s_i < S_m$ or market incompatible specialization at $s_i >> S_m$. Opportunities appearing through differing specialization intensities within the $S_m \pm f_m$ interval and, as a result, variance in market prices are exploited through simple arbitraging (see e.g. Kirzner 1973; 2009) that tends to equilibrate the market. The market is thus not static but will, as factors specialize in the interval $0 < d_i < f_m$, progress at moderate pace toward increased specialization.

Consider the entry into this market situation by a single resourceful entrepreneur e_1, who imagines a (in some sense) novel structure of production P_1 comprising specialized tasks t_{10}, t_{11}, t_{12}, t_{13}, and t_{14}. Assume e_1 trusts the design to be profitable and that it can only be established through combining factors specializing to a degree such that $d_i \geq f_m$ (or even $d_i >> f_m$) for all i. Further assume e_1 has access to the financial means necessary to realize the envisioned P_1. To bring about this imagined production structure, the entrepreneur induces all necessary i to forsake their current market positions to engage in extra-market specialization to the imagined tasks within P_1 under the entrepreneur's guidance. The entrepreneur provides a design or blueprint and imagined roles for the factors to fit in it—and contracts with factors to bring about the structure. The entrepreneur is therefore a visionary and promoter rather than a director or coordinator.

Under atomistic competition factors already occupy cost-effective positions in the market, so their offered remuneration in P_1 must exceed the normal rate of profit. The entrepreneur therefore must share part of estimated future profits with factors to establish P_1, from which we draw two important conclusions. First, there is an "infeasibility zone" (where $d_i \geq f_m$ but not $d_i >> f_m$) for imagined productive structures expected to generate above-market returns that *cannot* both provide factors sufficient remuneration and the entrepreneur adequate returns. Such projects constitute a productivity gain in resource use but ultimately generate below-market earnings and therefore will not be pursued. Hence entrepreneurial projects require high expected returns and are so expected to exploit productivity gains only from very high-intensity specialization. This conclusion reinforces the previous conjecture that firms in their internal structures are different from market-based production.

Second, the role of the entrepreneur cannot usefully be separated from that of the capitalist-investor (Rothbard [1985] 1997; [1962] 2004; Salerno 2008). The latter ultimately bears uncertainty through ownership; its "economic function is to put out money at risk for use by entrepreneurs and managers" (Manne 1967: 273). To establish the imagined structure, the entrepreneur must offer present goods as payment for future goods: factors do not willingly execute specialized tasks in the still-to-be-realized structure without present remuneration. The capitalist-entrepreneur, on the other hand, is the residual claimant (Grossman and Hart 1986; Hart and Moore 1990) who is awarded future profits if successful and risks losses if not (Mises [1949] 1998).

The entrepreneur is the ultimate coordinator in the firm and necessary for firm emergence—but not necessary for maintaining and operating the production structure (which requires factors and, likely, one or many managers). The imagined production structure of the original entrepreneur is realized through contracted managers and labor factors acting as "proxy-entrepreneurs" through engaging in lower-level coordination and co-specialization in accordance with the overall plan. We have therefore shown that while there is no explanation for how transaction costs cause firms to emerge, firms as "islands" of specialization can only be brought about through imaginative entrepreneurship. The firm here appears as a productive necessity due to limitations of the market.

Concluding Discussion

These conclusions constitute important pieces of the puzzle in the theory of the firm. The function of firms is here to provide entrepreneurs with "encapsulated" settings in which imagined and novel production capabilities can be established while in its specialized parts incompatible with the market. Such processes cannot be brought about through market contracts, since virtually all factors face severe disincentives through incompatibilities and transaction costs to attempt such specialization. More importantly, however, market contracting is insufficient to establish the high-density environment necessary for the extensive co-specialization process needed to establish a flawlessly functioning production process in accordance with the entrepreneurial plan, since such contracting lack both the vision and the necessary coordination. The continuous controlled experimenting that goes on within firms cannot be directed but must take place in a decentralized and cooperative fashion (Foss, et al. 2002; 2007; cf. Dyer, Gregersen and Christensen 2008); solutions to unforeseen problems are often found in the interaction between factors and proxy-entrepreneurs that continuously push for improvements (Foss and Foss 2002; Stern 2006), but rarely through top-down direction and the issuing of orders.

The firm can thus, while imagined and created by the entrepreneur, be seen as a product of its factors or resources acting to maximize performance through making continuous improvements and, thereby, creating and enhancing capabilities over time

(Penrose 1959; Wernerfelt 1984; cf. Foss 1996a; Helfat and Raubitschek 2000; Jacobides and Winter 2005). The firm should therefore be unique as well as evolving in its collection of resources or capital structure (Balakrishnan and Fox 1993), and therefore in its capabilities. In other words, the entrepreneur is dependent on employed factors to create the particularities of firm resources and how they fit together—and on managers to work out optimal combinations to attain the goals set in the entrepreneurial plan.

The fundamental reliance on co-specialization to realize and maintain profitable "islands" of specialization makes it necessary for the entrepreneur to establish task-specific yet open-ended employment before market contracts (rather than factors hiring their manager as in e.g. Alchian and Demsetz 1972; Jensen and Meckling 1976). The former supports and energizes the kind of micro-level experimenting and resource coordination efforts necessary to maximize performance and provide the firm with capabilities and competitive advantage; the latter offers only very limited incentives for experimentation and collaboration, and impedes overall optimization efforts by disallowing continuous management.

This chapter argues that there is much to gain from studying organizations from a specialization perspective, thereby focusing on the productive contribution of organizations as compared to the market. It is proposed that specialization is a unifying theme in studying the market, the firm, and entrepreneurship, in addition to being a cornerstone of our understanding of efficiency in production and a prerequisite for trade. The specialization perspective offers an interesting starting point from which a framework to develop a more complete theory of the firm may be built. The division of labor and capital suggests that there are limits to development and growth in the market due to restrictive compatibilities and interdependencies, and that they are important for the coordination of production processes. It also suggests an important role for the entrepreneur in organizing and, indirectly, in effectuating how production processes are arranged in the market.

The central contribution of this approach relates explicitly to the study of the firm. It offers important insights and clues that stand in direct contrast to transaction cost analysis and that significantly complement the resource based view and industry-positioning approaches. The firm is organized around unique or scarce resources that are purposefully specialized to attain certain ends and fill certain functions that are determined by the collection of resources within the firm; the distinct nature of a specific firm and its unique set of capabilities are a direct effect of resources being dedicated and specialized to certain ends—and their continuous co-specialization to solve specific problems and so further improve the firm's productive capabilities.

Moreover, this chapter shows that there may be reason to further investigate the sources of transaction costs and their real effects on entrepreneurial decision-making. Indeed, it is suggested that transaction costs may not sufficiently explain firm emergence, but provides primarily an *ex post* cost rationale for organizing. If corroborated, transaction cost analysis may explain lack of disintegration of firms, and therefore the tendency of markets to be primarily populated by production processes integrated in firms despite overall increased density.

SIMULATING THE ROLE OF SPECIALIZATION AT THE FIRM/MARKET BOUNDARY

Introduction

Why are there firms, and where do they come from? Coase (1937) famously asked this question arguing that economic theory assumes an order under which the price mechanism should be the sole efficient coordinator of transactions. Yet this is not what we see in the real market, where most transactions seem to take place within or between firms. Coase therefore sets out to bridge this gap in economic theory, “attempt[ing] to discover why a firm emerges at all in a specialised exchange economy” (1937: 390).

This chapter presents an agent-based simulation of the Coasean perception of the market and tests the transaction cost explanation to integration in firms. I specifically target how firms can *emerge* in the market place and contrast Coase’s transaction cost approach with the view that organizations are primarily a result of the division of labor, an idea that Coase found unconvincing or insufficient and therefore discounted.

In the next section, I argue that there is value in adopting the dynamic concept of emergence for studying the function and existence of firms instead of establishing the cost rationale for choices in static equilibrium. I then briefly discuss existing theories attempting to explain the rationale for and behavior of firms, and suggest that there is a common ground to these theories that is understudied. The following section introduces the method used for this inquiry, and argues why agent-based simulation is applicable on the particular questions raised in this chapter. I then introduce the basic design of the model used in the analysis, followed by a discussion of hypotheses. The results are then discussed along with notes of necessary changes to and modules added to the simulation model. I finally summarize my conclusions and discuss implications and potential questions to be answered in future research.

Emergence of Firms

Coase's point of departure to studying why there are firms is the theoretical construct he refers to as "atomistic competition" (1988c), a competitive market state where no transactions are carried out within integrated hierarchies. His theoretical starting point is akin to Williamson's conjecture that "in the beginning there were markets" (1975: 20), an original market state from which firms are allowed to emerge and their doing so can be explained. But while the transaction cost analysis of Coase and Williamson explains the comparative statics of when transactions are organized through market contracting and when they are integrated in firms, the theory does not attempt to analyze the cause and process of organizing. In other words, the Coasean question of "why" there are firms is potentially answered, but the closely related question of "how" firms emerge is ignored. The transaction cost theories of Coase and Williamson do not provide an explanation for what steps need to be taken from market coordination through the price mechanism to integration around a manager.

One possible reason for this is the transaction cost focus on *ex post* organizing and, in the words of Williamson, the optimal "governance choice" in different situations. The internal organizing of the firm, and hence the effects of the particularities of how it came about, is of secondary importance. In fact, it is indirectly only a consequence of changes in relative prices in the market: "[m]anagement proper," writes Coase (1937: 405), "merely reacts to price changes, rearranging the factors of production under its control." The Coasean firm is similar to comparable market transactions, since the "object of organization" is "to reproduce market conditions" (Coase 1988c: 4).

In contrast to the static or equilibrium-based ex post transaction cost analysis, the resource-based view (RBV) attempts to explain firms' internal organizing, and especially how firms combine and configure their resources in order to achieve competitive advantages to exploit entrepreneurial opportunities (Rumelt 1984; Barney 1986b; 1991; 1996). But whereas there have been resource-based attempts to formulate a theory, based on a perspective emphasizing entrepreneurial opportunities, of how and why firms are created (Alvarez and Barney 2002; 2005; 2007), the theory stops short of explaining step by step how firms emerge in the market place. Rather, the RBV aims to explain the evolution of firms' internal organizing, their constant (re)configuring and procuring of capital assets and resources to better adjust to perceived opportunities (Penrose 1959).

The question therefore remains unanswered: how do we get from the Coasean market of "atomistic competition" to a state of affairs where many or most transactions take place within or between firms? Put differently, what is the logic and the drivers behind the integration *process*?

Possible and Attempted Explanations

It seems an answer to these questions would need to stress the foci of both the transaction cost analysis (ex post maximizing choice of governance structure, in Williamson's view) and the RBV (maximizing of resources at hand through primarily reconfiguration). Interestingly, there is reason to argue that there is a common basis for the transaction cost theory of the firm and the RBV theory of internal organization. Jacobsen (2008) argues persuasively that Coase was heavily influenced by the work of Robinson (1931), and that the theory of the firm formulated by Coase, even though he significantly deviated from Robinson on certain issues, is arguably quite Robinsonian. Likewise, Jacobsen (2011) argues that the same Robinson was the main influence on Penrose (1959), who is a major precursor to and source of inspiration for the development of the RBV. Robinson's *The Structure of Competitive Industry* (1931), which influenced both Coase and Penrose, was part of a great emergent body of research in the 1920s and 1930s on the theory of the firm (Coase 1998: 62-63) and, especially for Robinson, the inquiry into issues such as the "optimal size" of firms.

Robinson, as did many prior to him, based his understanding of organization in the market on Adam Smith's (Smith [1776] 1976) recognition of the effects and importance of the division of labor, and made interesting contributions on the relationship between firm size and the division of management within firms. The focus on specialization through the division of labor is recurrent in the RBV, which focuses on the existence and importance of specialized resources and how they are configured and combined to create competitive advantages (Barney 1991). The congruence between specialization and Coasean transaction costs is less obvious since Coase seems to reject the division of labor as *explanans* for firm organizing while assuming a specialized exchange economy (1937; 1988c). But the transaction cost concept heavily relies on specialization, and the resource heterogeneity that it suggests, in order to create the "friction" in the market place that constitutes or gives rise to transaction costs ("marketing costs," in Coase's view). Coase furthermore argues that integration in firms is directly dependent on the relative location of resources in the market, and therefore that "[i]nventions which tend to bring factors of production nearer together, by lessening spatial distribution, tend to increase the size of the firm" (1937: 397; referring to Robinson 1931: 27-33). The firm is therefore at the same time a means to overcome yet subject to the transaction costs arising due to the heterogeneity and distribution of resources in the market, and its boundary is thus determined by this tradeoff (1937: 393-394). (Specialization is more obviously a factor in Williamson's (1975; 1985) depiction of transaction cost analyses, where "asset specificity" plays an important role in predicting integration of production processes.)

While indirectly placing great emphasis on the *effects* of specialization, neither of the two approaches emanating from the work of Robinson (following Jacobsen 2008; 2011), attempts to explain the firm—as Robinson attempted, however implicitly—using this concept. Recently, some attempts have been made to use resource heterogeneity and specialization to explain the existence of firms (Bylund 2011; Foss and Klein 2012; Lewin 1998; 2011), but the theoretical postulations have not been tested empirically or quantitatively. Of course, the lack of testing may be explained by the absence of data and means to construct economic experiments to study the formation of firms. Yet modern technology provides sufficient means to test several of the stated assumptions, some of the hypotheses, and the impact of specialization on a simplified model of the market and integration. This chapter aims to fill this gap and provide preliminary testing of the specialization reasoning in the aforementioned literature through agent-based simulation.

Agent-Based Simulation

Agent-based modeling techniques allow social scientists to construct dynamic experiments where such cannot otherwise be done in the real world and where the origins or causes of change to complex macro phenomena cannot be studied empirically. Such research has traditionally struggled with finding causal relationships, i.e. to identify the behavior and microfoundations of observable, complex, and dynamic phenomena. Agent-based simulation targets the dynamic causes of such "spontaneous" patterns that we observe in society and markets but that we cannot fully comprehend. Even though such computerized approaches have long been used in the behavioral sciences, they have only recently been adopted in management and entrepreneurship research (Meinhart 1966; Bonabeau 2002).

Through constructing simplified agents and allowing them to engage in rules-based interaction, agent-based models can simulate how social phenomena or self-enforcing patterns such as institutions and organizations emerge. In the language of Epstein & Axtell (1996), we "grow" societies from the bottom up and can therefore estimate the outcome of minor changes to individual agents or classes of agents and thereby study the sufficiency of characteristics. The reason for using this type of method is summarized by Axelrod and Tesfatsion (2006: 1649, p. 1649):

> Understanding a political or economic system requires more than an understanding of the individuals that comprise the system. It also requires understanding how the individuals interact with each other, and how the results can be more than the sum of the parts.

Agent-based computerized modeling can provide such understanding through creating artificial societies that consist of very simple agents that have a necessary minimum of attributes including the sort of characteristics that we wish to emphasize in our study. Through allowing agents to interact according to simple behavioral rules (such as "maximize profits" or "approach agents of opposite sex") we can benefit greatly from using this technique in "the study of human social phenomena, including trade, migration, group formation, combat, interaction with an environment, transmission of culture, propagation of disease, and population dynamics" (Epstein and Axtell 1996: 2). By basing the models in empirical data, we can overcome the problem of testing only artificial societies and thereby make the models relevant to research aiming to understand the real economy (Boero and Squazzoni 2005). Simulations and agent-based modeling have been used in management and entrepreneurship research to study several problems and phenomena, including decision-making and entrepreneurship in organizations (Lant and Mezias 1990; Küchle et al. 2006; Walter et al. 2006; Ross and Westgren 2009; Stahl and Zimmerer 1984), embeddedness, clustering and growth (Provance and Carayannis 2011; Zhang 2003; Wang, Liu and Dai 2010), and development of theory (McKelvey 2004; Crawford and McKelvey 2010)

The specific model used in this chapter will be discussed in detail below, but it is important to note the dynamic or evolutionary, and strictly bottom-up character of agent-based modeling. While we may construct simple agents in any way we wish, the results may not necessarily be predictable. In fact, the value of this method is that the patterns that arise from agent interaction are not perfectly known in at least their form, size, frequency, etc. The purpose of such computerized simulation is to "grow" the phenomena that appear "spontaneously" through agent interaction and thereby measure the effect of the change in magnitude of certain traits or attributes that are considered to be of particular interest. The macro level phenomena are in this sense, in the words of Adam Ferguson, the "result of human [agent] action, but not the execution of any human design" (Ferguson [1767] 1782: 205).

This method is particularly suitable for the social sciences, since the nature of social phenomena commonly do not allow for constructing controlled experiments and do not provide constant relationships permitting data-based testing (Weber 1949; see also Mises 1949). Especially research focusing dynamic processes could benefit greatly in adopting simulation to study the mechanics or patterns (see e.g., Wu et al. 2009; Zott 2003). Simulation provides a "third way" in which social science research can be carried out, in addition to argument and formalization (Gilbert and Terna 2000). While simulation can take many forms, the modern approach to use computerized agent-based simulations is likely the most powerful and advanced.

A common critique of computerized models such as agent-based modeling is the strict causality of computerized programming and therefore the risk of making the expected results part of the model. In other words, the question of whether implying the results in the structure of the model can teach us anything about the effects. It is a valid suspicion that turns out to have significantly less relevance than one would expect. The reason is that the model does not include the macro concepts that are studied: the concepts are generated only through running the model and the model itself includes only simple, local rules of behavior that have no direct bearing on the well-known macro phenomenon that is studied. Epstein & Axtell mention the reason this criticism is oftentimes inapplicable; in fact, there is no and should be no surprise in the outcome (the macro-level phenomenon), at least not in its general form—the surprise and contribution is in *how it is generated*. It is the process itself and what drives the process that is the core to simulation studies:

> The surprise consists precisely in the emergence of familiar macrostructures *from the bottom up*—from simple local rules that outwardly appear quite remote from the social or collective phenomena they generate. In short, *it is not the emergent macroscopic object per se that is surprising, but the generative sufficiency of the simple local rules*. (Epstein and Axtell 1996: 51-52; emphasis in original)

At the core of agent-based modeling lies the fact that there is no macro-level phenomenon implemented in the model, but only independent agents (inter)acting according to simple, local rules. Within a class of agents, all individuals are exactly the same in terms of behavioral rules but may differ in their respective attribute values. It is only through agent interaction that macro phenomena are "grown," which is how this method should be used in social science research: through the elementary rules for simple, streamlined agent interaction we can study the *sufficiency* of these rules in bringing about the macro phenomenon we observe empirically.

This is also the purpose of using this method in the research project discussed in this chapter: we wish to investigate the motivation for transaction cost reasoning in firm organizing. In other words, our aim is to examine the Coasean system from the point of view of the pre-Coasean explanation in order to determine whether transaction costs are, as Coase proposed, necessary to explain integration of production processes. From an agent-based modeling point of view, this translates into the question of whether specialization and the division of labor can sufficiently explain the integrated macro phenomenon of firms. Coase states:

> In view of the fact that while economists treat the price mechanism as a co-ordinating instrument, they also admit the co-ordinating function of the "entrepreneur," it is surely important to enquire why co-ordination is the work of the price mechanism in one case and of the entrepreneur in another. The purpose of this paper is to bridge what appears to be a gap in economic theory between the assumption (made for some purposes) that resources are allocated by means of the price mechanism and the assumption (made for other purposes) that this allocation is dependent on the entrepreneur-co-ordinator [manager]. (1937: 389)

Indeed, we adopt the same purpose, but we also attempt—in contrast to Coase—to investigate whether specialization in the hands of the entrepreneur can sufficiently explain integration. Consequently, we scrutinize whether transaction costs are necessary for integration. Like Aggarwal, Siggelkow and Singh (2011), we discuss the simulation model, hypotheses, and results in separate sections. However, since the tests are cumulative we first discuss the basic model, then the hypotheses and implementation, and finally the results section, which includes a discussion on adaptations to the simulation model in order to properly test the previously stated hypotheses.

The Simulation Model

The model is based on the Coasean perception of the market according to economic theory. States Coase, "if there were atomistic competition, where every transaction involving the use of another's labour, materials or money was the subject of a market transaction, there would be no need for an organization" (1988c: 4). Coase describes this theoretical market as follows,

> The economic system 'works itself.' This does not mean that there is no planning by individuals. These exercise foresight and choose between alternatives. This is necessarily so if there is to be order in the system. (Coase 1937: 387)

In other words, the market place provides a framework for order notwithstanding the lack of formal organization. In this specialized exchange economy even the more elaborate or complex production processes are established through market contracting between independent ("self-employed") actors. Coordination of individual actions is here effectuated through trade and, ultimately, through the price mechanism.

In this model, this situation is represented by a market of 200 actors randomly spread out over a 100x100 torus space through which the Coasean transaction cost theory, including the effects of marketing costs, heterogeneity, and spatial distribution, can be tested. The actors are randomly assigned a role in an advanced production process represented by the production interval (0-5) consisting of five serially interdependent production stages: (0-1), (1-2), (2-3), (3-4), and (4-5). Each agent is also initially given a random amount of funds and inputs so that the simulation immediately represents a market place. Also, agents are told to walk randomly across this space one step at a time unless they see a potential trading partner.

The agents' vision is limited to two steps in each of four directions (N, S, W, E), the limitation of which represents the lack of omniscience in real markets in line with

Coase's consistent emphasis on the importance of realism in economic theory (Hsiung and Gunning 2002; see also e.g., Mäki 1998; Mäki 2002). Coase stresses that he wants his theory of the firm to be "realistic in that it corresponds to what is meant by a firm in the real world" (Coase 1937: 386). While the non-omniscience limitation can possibly be interpreted as a transaction cost in itself, doing so would seem to accept an overly broad definition of the concept that by its nearly limitless scope grants the transaction cost concept explanatory power to any and all phenomena in the real market—and thereby makes it difficult if not impossible to falsify.

Even so, in Coase's treatment transaction costs are always present in the market—even under the starting position atomistic competition—but drives integration only when higher than the costs of organizing by some magnitude. The costs of organizing primarily have to do with the bounded rationality of the firm coordinator in terms of decreasing returns to management and its inability to properly reproduce the market's resource allocation. The nature of these costs considerably adds to the complexity of the model while their implementation would not grant additional explanatory power in terms of firm emergence. For the sake of simplicity, it is assumed that "transaction costs" due to non-omniscience in this model always tend to equal organizing costs, or at least that they are insufficiently large to cause firm creation, and therefore can be excluded from the analysis. Granted, the limited vision of agents is a limitation that goes beyond the transaction cost analysis in Coase (1960) through imposing "costs" of imperfect information.

This configuration is more in line with the original analysis of integration in Coase (1937) where there "is a cost of using the price mechanism," and especially "of discovering what the relevant prices are" (1937: 390), but where these costs cause integration only at certain magnitudes. Agents' limited vision should not compromise the conclusions since our objective is to elucidate the mechanisms behind firm emergence—which requires transaction costs of magnitude—using reasoning from the Coasean framework. This does not require full implementation of the details of the Coasean system. The effects of expanding the vision of agents is an interesting expansion of this model, which should be studied in future research. Yet doing so is beyond the scope of the task undertaken in this chapter.

The agents in the model, limited in their vision, are instructed to refrain from moving if they are already located next to the best possible trading partner willing (and able) to sell inputs or purchase outputs (subject to the actor's current needs). The reason should be obvious: all trade opportunities entail gains from trade, and there is no reason to move unless the agent either has no possibility for exchange or is already aware of a superior opportunity. As in the real world, agents cannot move to a location that is already inhabited by another agent.

In order to establish a full production process, we need to take inputs through each of the stages in sequential order. To allow for heterogeneity in agent competencies and effectiveness, each agent is randomly assigned a production stage as well as additional competence; an agent may therefore have the "ability" to produce stage 3 (the interval 2.00-3.00), but is competent to produce from 1.80 through 3.15. This way, we will find that agents have "overlapping" competencies that ultimately increases compatibility with trading partners as well as allows for potential negotiation of "who does what." Agents negotiate a sales price at the midpoint of the overlapping area so that the price in a transaction where agent *A*, with competence to produce 1.80-3.15, sells products to agent *B*, with competence 2.90-4.05, at the price (3.15 - 2.90) / 2 = 3.025. Prices in the market therefore fluctuate somewhat, and the agents can choose among multiple trading partners depending on these price "negotiations." The quantity sold in the transaction is limited by the products in *A*'s stock and *B*'s funds.

The cost of production is calculated for the selling party at the time of sales, and is calculated as a percentage of his competence interval (in the case of A, this would be 3.15 - 1.80 = 1.35) adjusted for his or her "experience" (the number of previously sold products) and—for the sake of realism and in order to simulate heterogeneous behavior among actors—a measure of risk aversion. Through these measures, the simulation allows for increased productivity with experience so that the cost of production is lower the more "experienced" the agent. Production is assumed to be instantaneous to facilitate voluminous trade on the landscape. The agents are furthermore instructed to first trade with the most profitable trading partner if located adjacent to more than one compatible agent.

The basic design of the model is summarized as follows:

- Market space: 100x100 torus space (10,000 positions)
- 200 agents (randomly distributed; see Table 1)
- 5 production intervals (0-1, 1-2, 2-3, 3-4, 4-5; randomly assigned)

Agents go through the following sequence of actions:

1. Next to trading partner(s)?
    a. Yes: go to (3)
    b. No: go to (2)
2. *Scan landscape.* See trading partner(s)?

   a. Yes: prioritize according to profitability; take one step in direction of most profitable partner
   b. No: take one step in random direction
3. If next to trading partner(s):
   a. Identify direction(s) of trading partner(s)
   b. Prioritize based on most profitable partner
   c. Conduct trade (in priority order)

Variable	Type	Default value
Position	coordinate	[random]
Stock	real	[random, 0-10]
MoneyOnHand	money	[random, 0-10]
Experience	int	0
ProductionIntervalLowerLimit	real	[random]
ProductionIntervalUpperLimit	real	[random]
RiskAversion	int	[random, 0-10]
TotalIncome	real	0
TotalOutlays	real	0
TotalProductionCost	real	0
TotalProfit	real	0

Table 1. *Agent configuration: variables with types and default (initial) values. Total sales is measured through the agent's experience.*

Testing of hypotheses is carried out through running the same simulation numerous times in order to account for any arbitrary effects of random spatial distribution of agents and their respective competencies (including distribution of assigned production stages) and initial assets. While the results of any individual run may differ somewhat from previous individual runs, the repetitive testing produces results that should converge around the mean. We consequently report below the definitive results of this testing process rather than the outcome of any individual runs. But we first discuss the hypotheses to be tested.

Hypotheses

The first hypotheses are based on the starting point in Coase's analysis, a market situation under atomistic competition. In this market transaction costs are of insignificant magnitude and therefore do not drive integration. In this simulation, this state of the market is interpreted as a prediction that there should emerge no lasting "islands" or groups of agents. As agents wander randomly across the torus space searching for trading partners, they will trade with whomever they meet that is compatible for trade. However, it is conceivable that agents temporarily form full production chains spanning all production stages. But such structures are not lasting, since other agents with more attractive competencies or assets would break up any such patterns.

The first hypothesis therefore states:

H_1 : *In a zero or low transaction cost world, agents will not form lasting production structures. Instead, the market will find a stable equilibrium in "atomistic competition" without persisting multi-agent (firm-like) production structures.*

The second hypothesis reformulates Coase's thesis for integrating production structures in firms in a world with positive transaction costs of significant magnitudes. The "cost of using the price mechanism" (Coase 1937: 390) makes it less costly to integrate production processes in a firm where a central planning authority—the manager, who Coase calls the "entrepreneur-coordinator"—directs labor workers. But the difference between firm and market lies primarily in what is the coordinating force, not in the allocation of resources in the production process. Coase explicitly states that the purpose of firm organizing is "to reproduce distribution of factors under atomistic competition within the business unit" (1988c: 4). We can therefore assume the same type of capital and labor structure for production coordinated within a firm as in the market through the price mechanism.

While Coase discusses the rationale for firms in the market but does not explore how firms would emerge, we will here test whether Coasean transaction costs bring about stable, firm-like islands of agents. At a minimum, a stable island must comprise two serially dependent production stages (agents) to be considered vertically integrated. But it does not need to comprise the whole production process, since Coase does not suggest full vertical integration. Testing this necessitates a minor change to the simulation model used in the previous hypothesis, which we discuss in the next section.

Following the general reasoning behind the transaction cost theory of the firm, the second hypothesis is as follows:

H_2 : *In a positive transaction cost world, agents form relationships with adjacent trading partners and establish production structures that persist over time. The market will find a stable equilibrium in a multitude "islands" of multi-agent (firm-like) production structures.*

The third hypothesis follows from the negation or critique of the Coasean position while suggesting a potential cause of transaction costs. Following the identification in RBV that the market consists primarily of heterogeneous resources, we adjust the structure of the simulation to test different degrees (intensities) of specialization in the production process. This is done through considering different levels of roundaboutness (number of stages) to track the effects of specialization, in which we assign agents more narrow (or broader) intervals for production. In other words, whereas the agents initially were assigned one of five fixed production stages, we test the effect of giving agents overall smaller and greater abilities thereby lengthening and shortening the production process. Obviously, a "longer" or more roundabout production process (say, with a doubled number of more narrowly defined production stages) puts more strain on production in the market through being more difficult to establish—the agents should be less likely to (or less frequently) find compatible trading partners. At the same time, each production stage should produce greater output and at lower cost (Young 1928). In other words, a highly specialized economy should suffer from high transaction costs but benefit from greater efficiency in production of each stage.

Similarly, "shorter" production processes would ultimately lead to increased inter-agent compatibility (and thus make trade easier or less costly) while efficiency in production may suffer. Also, single-stage production processes entail virtual non-specialization through homogeneity and therefore make gains from trade impossible. Incentives to exchange in production fade and the interdependence of producing actors is therefore neutralized. To summarize: specialization is a prerequisite to trade, but under-specialization is costly due to poor utilization of resources and inefficiencies, while over-specialization increases costs to exchanging.

The hypotheses are as follows:

H_{3A} : The shorter (less roundabout) the production process, the more frequent the exchanges and so the smaller impact of transaction costs on transacting.

H_{3B} : The longer (more roundabout) the production process, the less frequent the exchanges and so the greater impact of transaction costs on transacting.

The final hypotheses are formulated to test the effect of imaginative entrepreneurs in the market. We saw above how Coase bases his reasoning on the initial distinction between two coordinative functions in the market place: the price mechanism and the "entrepreneur." Coase's contribution was the identification of transaction costs and how they provide an opportunity for the entrepreneur to utilize managerial planning to economize on transaction costs. Indeed, Coase's argument is that the price mechanism is costly and that its [transaction] costs can be avoided through allocating resources using centralized direction instead of relying on the decentralized "atomistic" rearrangement of resources guided by changes in relative prices.

Coase's argument, however, is an argument for integration of production processes as a means to primarily (or only) economize on transaction costs in the market. Resources in the firm are allocated in accordance with the relative prices in the market, and is therefore similar (if not identical) to the market in terms of resource structure, but the firm overrides the market's transaction costs through relying on managerial direction. To test the emergence of firms in the market (rather than provide an *ex post* rationale for integrated units), we add a (very small) chance for agents to innovate (Schumpeter [1911] 1934) new production structures and, as entrepreneurs, pursue them through building persisting alliances (which we equate with establishing firms).

We follow Bylund (2011), Lewin (2011), and Foss & Klein (2012) in their conception of the firm as primarily a collection of heterogeneous resources combined and configured by a judgmental entrepreneur (Foss, et al. 2002; 2007; Kor, Mahoney and Michael 2007), placing entrepreneurial *judgment* at the center of what is the firm. Firms are thereby not merely a mirror image of the market's allocation of resources, but are different in terms of structure and purpose. Also, the entrepreneur has the original vision, takes action to realize it through the firm, and bears the uncertainty of the investment (Cantillon [1755] 2010; Mises 1949). We furthermore emphasize the importance of resource heterogeneity and imagine firms as "islands of specialization" where entrepreneurs utilize the efficiency of more intensive divisions of labor to compete with production coordinated through individual exchanges and/or contracting. We expect firms to be profitable and therefore stable over time, even if resources (agents acting like "employees") in firms constantly reassess their economic situation.

We hypothesize, in accordance with transaction cost theory, the following:

H_{4A} : *In a positive transaction cost world, agents form relationships with judgmental entrepreneurs and become part of production structures that persist over time. The market will find stable equilibrium in a multitude of "islands" of multi-agent (firm-like) production structures.*

In addition, we hypothesize the negation of the above hypothesis H_{4A} to separate the effect of transaction costs from that of entrepreneur-generated specialization:

H_{4B} : *In a zero (or low) transaction cost world, agents do not form relationships with judgmental entrepreneurs or become part of production structures that persist over time. The market will find stable equilibrium with no lasting "islands" of multi-agent (firm-like) production structures.*

Testing and Results

In the simulation tests, agents with competence to produce the initial production stage (0) have their available inputs refilled every time their stock is depleted through sales and agents with competence to produce the final stage (4) automatically sell their outputs at the end of each run to a negotiated price halfway between the production stage endpoint and the agents' competence upper level. The rationale behind this choice is that we wish to test primarily trade through the specialized production structure, to which factor availability and consumer demand are not necessarily relevant. The effect is that the simulated market cannot at any time run out of inputs or fail to sell the end-product.

A pre-test simulation relieves the agents from the instruction to prioritize with whom to trade if adjacent to several potential trading partners. We do this to test the assumption of profit maximization: if agents are not maximizing their trades but only have, as in Adam Smith's *magnum opus*, a "propensity to truck, barter, and exchange" (Smith [1776] 1976: 17), then we would expect agents to stay close to one another but not have incentives to change trading partners. If all that matters to agents is trade but not profit, then trading is sufficient independent of alternative profit opportunities, which would have severe consequences for the simulation results. The test confirms the suspicion and agents very quickly form large groups where typically 98-99% of the agents bundle together in 2-3 massive groups that persist throughout the simulation run. The remaining 1-2% seem left out due to being incompatible with all agents populating the boundaries of these "societies" and wander seemingly endlessly across the torus space.

The following simulation test includes the profit motive through instructing agents to prioritize trade with agents offering the highest price for outputs or lowest price for inputs. Agents are furthermore instructed to in each run (if applicable) first sell outputs and then buy inputs, and to do so only with the best possible trading partner (prioritize profit over trade). The strict order of transacting introduces a lag such that purchased inputs cannot immediately be sold as outputs, which adds a temporal dimension to the market. While this also adds strain to spontaneous groups of agents, since the lag forces them to sell outputs produced from inputs that were acquired no later than in the previous run, it is more realistic than temporally independent interaction. Transaction costs are still kept at or very close to zero using the interpretation stated above.

In contrast to the pre-test simulation run, the simulation to test H_1 does not immediately create a few large "societies" of agents. The outcome is however the same: the process is slower and "islands" of agents are at first somewhat volatile and sometimes change shape or composition, but stabilize over time. The simulation finds an equilibrium state with several groups of differing sizes comprising approximately 95% of the agent population. The remaining 5% remain atomistically competitive and do not become members of any group, which is due to incompatibility with the agents at the islands' boundaries. The islands remain intact throughout the simulation but with occasional changes in agent positions at the boundaries.

This result is shown in Figure 6 below in the form of a simulation snapshot. Following Epstein and Axtell (1996) and Macal and North (2009), test results are illustrated with snapshot images of typical simulation runs throughout the chapter.

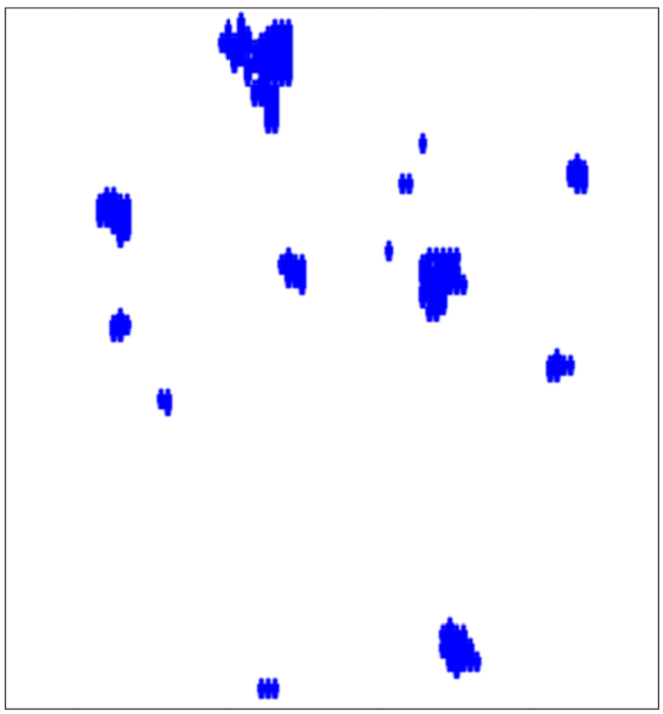

Figure 6. *Typical result of simulation model version #1*

The aforementioned islands seem to form around agents supplying the market with the first production stage (0). To test this notion and add further realism to the model, we add a lag to input availability for this class of agents. Rather than being endowed with virtually unlimited inputs, agents specializing in the first production stage have to wait until the subsequent run to see their stocks refilled. All other instructions to agents and simulation parameters remain the same.

This minor change has major consequences. As can be seen from Figure 7 below, islands of agents are no longer created and all agents remain atomistically competitive and independent over time. Only for brief moments do some agents stay together for more than one run to trade. This seems to always include agents with competence for production stages 0 and 1, and coincides with renewed input endowments for the former.

There are no noticeable differences in terms of agent welfare over time, which suggests that the changes made to the simulation add realism but do not significantly make agents worse off in a zero/low transaction cost market.

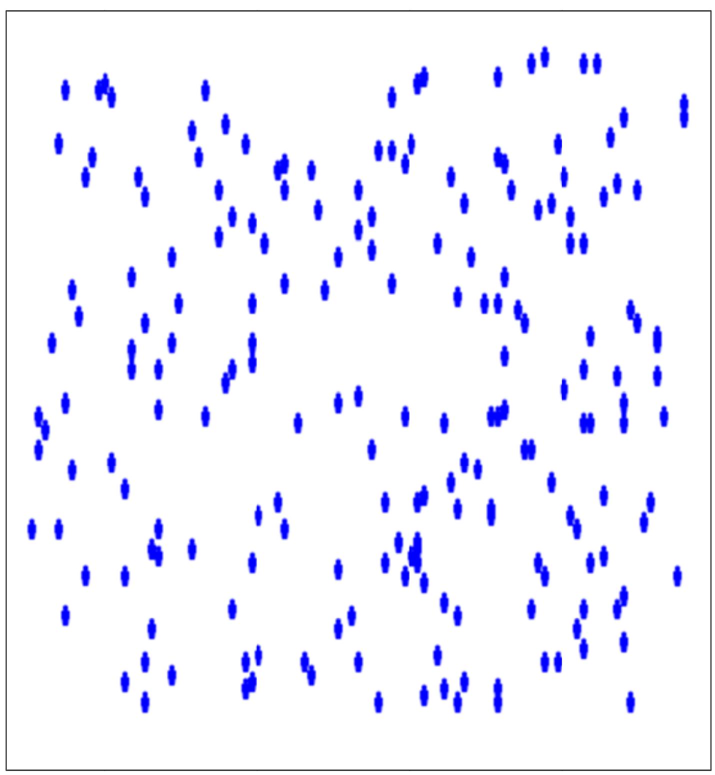

Figure 7. *Typical result of simulation model version #2*

We therefore fail to reject H_1 where agents are not endowed with unlimited resources and where they are guided by the profit motive. In other words, the simulation seems to corroborate Coase's argument (and his interpretation of economic theory) that vertical integration does not occur on a market with zero/low transaction costs.

The Effect of Transaction Costs

We implement transaction costs through first adding a cost (subtracting from an agent's funds at hand) every time the agent travels across the space. Following Coase's definition of transaction costs as "costs of marketing in the open market" (Coase 1937: 395), i.e. due to search across the market space, we implement this cost as affecting the agent any time he or she is not adjacent to a trading partner. In other words, we assume vicinity and ongoing exchange sufficiently resembles what we refer to as a firm, and we therefore make this situation cheaper than traveling through the market "looking for" trading partners. This also means that agents are not able to move (search) unless they have sufficient funds to cover one step's worth of transaction costs. Agents are hence expected to stop, and hence only passively engage in trade (i.e., when a trading partner approaches them), when they run out of available funds due to transaction costs.

In a second and alterative implementation of transaction costs, we follow Coase's later definition of transaction costs as those arising in order to "carry out a market transaction" and thus "to discover who it is that one wishes to deal with, to inform people that one wishes to deal and on what terms, to conduct negotiations leading up to a bargain, to draw up the contract, to undertake the inspection needed to make sure that the terms of the contract are being observed, and so on" (Coase 1960: 15). According to this slightly different and more elaborate (or perhaps simply more specific) definition of transaction costs, we must not only consider the cost for agents "marketing" themselves, but also the cost of contracting (i.e., communicating and establishing terms and prices). This transaction cost is implemented as a cost affecting the selling party at the close of every transaction, thereby reducing its income.

We test H_2 through running three similar configurations of the simulation model. The first configuration implements a fixed and universal transaction cost as search cost, which affects all agents equally. Testing at different magnitudes of transaction costs, the outcome appears stable: some agents remain in their current location while others move across the torus space to find trading partners. When a moving agent finds and trades with a non-moving agent, the latter (if selling) transforms into a moving agent since its funds on hand increases and therefore has sufficient funds to move (search) again. Only agents running out of funds stop moving, which eventually leads to a complete standstill in the market place with only passive agents. Even at very low transaction costs of this type, the whole market eventually subsides from a moving frenzy of activity to a landscape of frozen, non-moving agents. They do not at any time or at any magnitude of transaction costs form stable production structures, but their stopping and assuming a non-moving position quickly stops wealth creation in the market.

The second configuration of the simulation takes into account that transaction costs can be of different magnitudes for individual actors. Coase seems to allow for transaction costs to be different for different actors depending on their particular spatial position in the market (which, in our simulation as in the real world is unique and exclusive). Interestingly, "personalized" transaction costs in our implementation would have a similar effect on the functioning of the market as individual risk aversion levels connected with travel and search across the market place. To transaction costs for finding potential trading partners that differ between actors, we assign random values to each agent as their personal (unchanging) transaction cost.

The effect of this configuration is no different from the previous: as time progresses, an increasing number of agents assume a non-moving position in the market—and progressively fewer agents are pushed into moving through the market as moving agents exchange with them. Interestingly, agents tend to stop moving at locations not adjacent to other actors. Despite our agents' lacking ability to "look" diagonally (since they can only "see" in four directions across the space), they stop in locations that are evenly distributed across the space—with what seems to be a global maximization of space between any pair of actors.

The third configuration implements the view of transaction costs as direct costs of carrying out a transaction, especially the costs of contracting and negotiation of terms and prices. We implement this as a "tax" on each transaction so that a fraction of the funds changing hands in the particular transaction is never received by the seller (but, of course, is withdrawn from the buyer's "account"). In this sense, each transaction is made more costly (simulating costs of negotiating, contracting, and execution of the transaction) and this should have an impeding effect on the profitability of transacting. However, since our simulation interprets firms as "clusters" of agents transacting, this indirectly (and unfortunately) translates into a cost on firms. As we wish to test the *emergence* of firms under transaction costs (i.e., the "clustering" process step by step as agents "choose" to stay with trading partners), we cannot get around this problem without forcing agents into integrated structures. But doing so would undermine the logic of simulation testing and severely limit the model's explanatory power.

However, if transaction costs are avoided in trading relationships (i.e., as is the case in the first configuration above), such relationships would only be lasting if the integrated unit can endlessly tap into both inputs as well as sell outputs. As was the case in the first configuration above, agents tend to not stay in "trading positions." The reason for this is that what drives agents is their quest for profit through trade; unless a multi-agent constellation has access to sufficient upstream supply *and* downstream demand, the structure disintegrates. This result is interesting, since it suggests that common trading relationships are too weak to sufficiently form firm-like relationships despite the effect of transaction costs. While this can be overcome through distinguishing between market (weak) and employment (strong) contracts, this was never Coase's intent. Indeed, Coase believes fu.

In any case, we find that when transaction cost magnitudes are set sufficiently low, the impeding effect does not fully stop activity until after a significant period of time. The impact should however be clear: transaction costs impede and ultimately stop market activity and movement—and exchange (especially when implemented as a cost on transacting). Agents tend to assume non-moving positions when transaction costs finally drain their funds. In other words, transaction costs tend to effectuate penalties on agents who do *not* trade and thereby will have their funds depleted with no chance for profit, whereas Coase's supposed reasoning behind the "costs of carrying out a transaction" in the market place is quite the opposite. Coase asserts that it is costly to figure out what the relevant prices are in the market, which is ultimately a cost to market transactions, but seems to pay no attention to whether trading is *profitable*. In contrast, and as shown in this simulation, a cost to market transactions combined with profits from transacting seems to bring about an even distribution of actors rather than bring them together. It is difficult and quite problematic to draw far-reaching conclusions from the results of this simulation, but we can safely reject the Coasean hypothesis as transaction costs do not at all appear to cause integration. Unless there are additional gains from vertical integration than simple transaction cost avoidance, firms do not emerge.

The Effect of Specialization

We test the third hypotheses through running several different configurations of the simulation where we adjust the length of the production process in number of production stages. Each of the configurations is compared to each other as well as the original production process consisting of five serially interdependent stages. As expected, the impact of transaction costs on agents' movement across the landscape is increased as production processes are longer and vice versa when they are shorter. The effect is that agents in a highly specialized market suffer greatly from transaction costs and market activity consequently stops after only a brief time; the effect varies with the magnitude of transaction costs, but the tendency is consistent for all magnitudes.

Even when running the simulation at very low transaction costs, we see the same tendency. While the model offers no conclusive evidence on this point, it seems highly specialized markets suffer from implicit transaction costs through incompatibilities that impede exchange. In other words, the more highly market agents are specialized the higher the implied transaction costs through longer (search) time between transactions and thus lower overall profitability.

For shorter production processes, we found greater volumes of transactions as a result of shorter search times (agents are trade-compatible with a greater part of the market) and, therefore, more opportunities to engage in transactions with trading partners. Consequently, agents experienced overall higher profitability as a consequence of the higher volume and the smaller impact of transaction costs than in runs with more roundabout production processes. In the tests, however, the implemented lag for "automatic" refills of inputs for those with ability to produce the first stage in the production process had an increasingly slowing effect on the market so that the production time to complete a whole chain of production stages tended to increase. As time passed, therefore, the number of transactions decreased and search times consequently increased—and the effect of transaction costs increased.

Overall, the tests fail to reject both hypothesis *3A* and *3B*, and this seems to suggest that there is a seemingly strong positive relationship between specialization and transaction costs. While more testing is undoubtedly necessary to establish the link—and whether there is a *causal* relationship—between specialization and transaction costs (yet not within the scope of this chapter), the implications of our simulation model suggest that such research may be both meaningful and valuable.

The Effect of Entrepreneurs

In order to test hypotheses H_{4A} and H_{4B}, the simulation is expanded with a module supporting functionality that creates innovator-entrepreneurs and structured alliances between agents. Entrepreneurship is implemented as agents randomly "realizing" how to split their production stage into two separate tasks and then, equally at random, how to further split tasks into up to five tasks of equal size. Entrepreneurs behave like common agents until they see and make contact with agents with ability to produce the same production stage (i.e., who are compatible for employment to produce part of the production stage). They then invite the agent to become part of the firm, and they openly declare what payment the agent may expect. The agent compares the offer with his or her experiential knowledge of profitability in trading independently in the market, adjusted for the lesser risk inside the firm, and decides whether to join the firm (the same procedure is executed every time an "employee" encounters potential trading partners, and the agent may therefore at any time choose to leave the firm if not sufficiently profitable). If the agent chooses to join the firm, the firm's production ability interval is expanded to the degree the incoming agent's ability entails lower minimum or higher maximum.

The agents' sequence of actions in each round is thus modified as follows:

1. Next to trading partner(s)?
    a. Yes: go to (4)
    b. No: go to (2)
2. *Scan landscape.* See trading partner(s)?
    a. Yes: go to (3)
    b. No: go to (4)
3. *Compare profitability, prioritize*. Is trade with prioritized trading partner more profitable than employment in firm?
    a. Yes: Leave firm, take one step in direction of partner

b. No: go to (4)

4. If next to trading partner(s):

   a. Identify direction(s) of trading partner(s)

   b. Prioritize based on most profitable partner using firm's values

   c. Conduct trade through entrepreneur (in priority order)

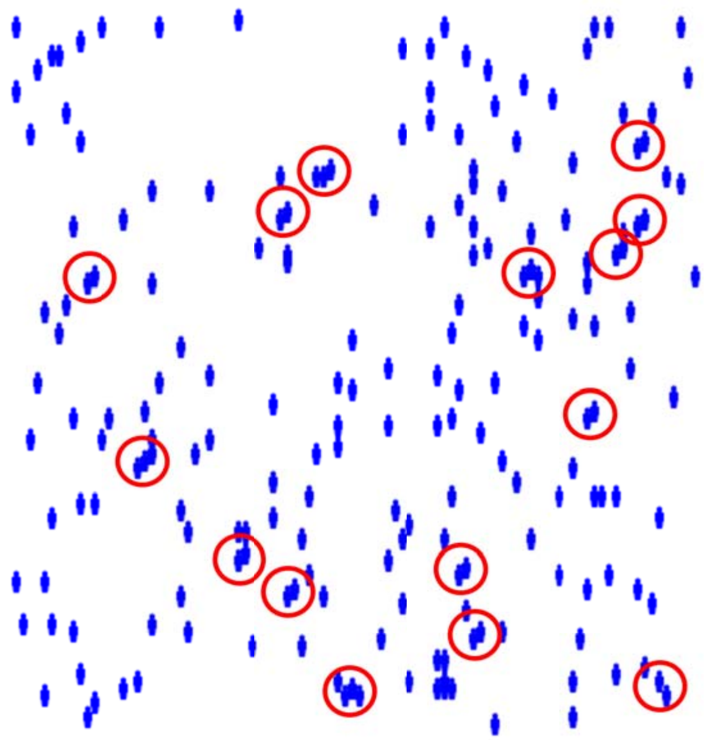

Figure 8. *"Firms" (circled) established around entrepreneurs*

Firms do not move across the torus space: the agents "within" the firm form stable structures with which atomistic agents (who do move) may trade. While this minimizes the complexity in implementation and therefore the difference in the simulation's programming between atomistic competition and firm emergence, it also suggests a possible limitation to the study, since firms will not be able to trade with other firms unless they happen to be located adjacent to each other. As we are not studying inter-firm trade but *firm emergence*, this limitation is deemed to be minor; also, the limiting effect is further reduced through placing "employees" diagonally from the entrepreneur, which means firms cover a comparatively larger area and therefore are susceptible for trade with moving agents. (Recall that agents' vision is restricted to four directions, which means the chances an X-shaped firm with one entrepreneur at the center and four "employees"—located to the northeast, southeast, southwest, and northwest, respectively, from the entrepreneur—will have greatly increased chances of finding trading partners.) In addition, this implementation suggests a comparatively strong requirement for lasting firms arising due to "employees" being free to leave the firm at any time by moving toward an agent that offers gains from trade that exceed the benefits of "employment."

All exchanges with firms are with the entrepreneur, even if channeled through one of the "employees." This means any firm will be centralized in terms of pricing, cost, storage of inputs, and trading experience, which suggests that it may be more profitable than atomistic agents (as proposed by the Coasean theory of the firm). It also suggests increased efficiency (lower cost, maintained production and profitability) through increased experience and tighter co-specialization through experimenting.

The alliance of agents (the firm) around an entrepreneur is implemented based on commission-based pay (i.e. profit sharing between alliance partners). This is implemented through the entrepreneur accumulating profits from trade that are then shared with "employees" after operative costs are covered. As part of these operating costs, we have—in addition to production costs—included an amount equal to the entrepreneur's risk aversion. As for atomistic agents, this is a cost of uncertainty that we may interpret as the cost of capital, organizing, etc. "Employees" are relieved of this cost as they become part of the firm, but as entrepreneurs are often—especially *judgmental* entrepreneurs (Knight [1921] 1985; 1942)—depicted as primarily uncertainty bearing they assume this cost.

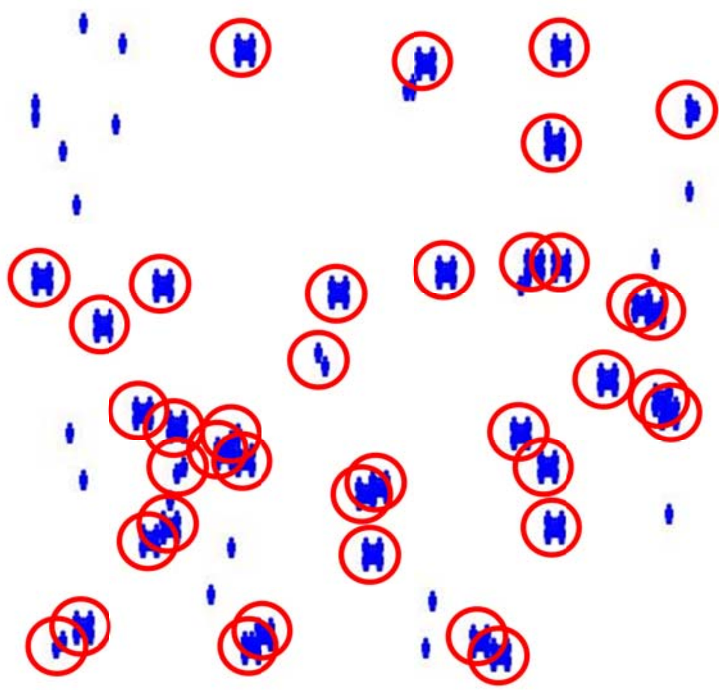

Figure 9. *"Firms" (circled) at a late stage in the simulation*

In accordance with Stigler's (1951) thesis (also adopted in Bylund 2011) that integration precedes advanced markets for specialized goods and services, and following the fact that there can be no market for employment before there are firms competing for labor factors, we have chosen to implement a looser and more flexible conception of the firm. The object is to study and simulate the emergence of firms, and we consider the step from a Coasean atomistic competition to a market landscape populated (at least partially) by firm structures in the sense of entrepreneurially established "islands of specialization" of foremost importance. Self-employed agents cannot themselves divide their production stage into several separate tasks, but depend on entrepreneurship to do so; the integrated firm is thus structurally different from market contracting even though "employees" are offered payment as commission of sales/production (share in profits).

The step from such structures to structures adopting a system of compensation through wages is comparatively minor—what we are interested in is the process of integration, not necessarily the exact nature of outcomes of this process. Similarly, it seems intuitive that a real integration process in the market to firm-like structures could initially take a form of close-proximity alliances rather than formal hierarchies based on authority through employment contracts (especially if the legal implications of the latter are different from market contracts). Since modern organizations seem to develop toward less hierarchical, network-based structures with pay-for-performance, strict wage-based employment may be too limiting in the analysis—our chosen implementation should in any case be sufficient for our purposes, since it allows integrated alliances to be the outcome of an overall integration process.

In our simulation tests, we fail to reject hypothesis H_{4A}. Agents tend to join judgmental entrepreneurs to form firm-like structures—and they persist over time. This suggests that agents find it initially profitable to join entrepreneurs in firms and that firms remain more profitable than any encountered opportunities in the market. Interestingly, the results are the same independently of the complexity of the production structure and, consequently, the number of agents sharing firm profits. A firm consisting of one entrepreneur and one agent is as likely to persist over time as a firm consisting of one entrepreneur and four agents (the maximum in this simulation). The results are also consistent regardless of the magnitude of transaction costs, which suggests transaction costs may not have a great impact on organizing.

Tracking profitability (money on hand) of atomistic agents, entrepreneurs, and agents within firms, we find that newly formed firms provide entrepreneurs with higher profits than agents acting in the market. We further find that "employees" often are negatively affected (lower profitability) immediately after joining a firm (but apparently not sufficiently so to *leave* the firm), but that they quickly increase profitability as production volumes pick up. The only difference in profitability between entrepreneurs and "employees" is the entrepreneur's additional allowance (to cover cost of capital, etc.), which suggests that profitability within the firm is close to profitability in the market. In other words, a firm splitting a task into two (or more) can thereby (in our implementation) support two (or more) agents—the entrepreneur and the "employee"—while getting approximately the same income per sold good. Firms therefore appear much more profitable than individual production, which may be a result of avoiding transaction costs or productivity gains through increased specialization.

It should be noted that the simulation grants only very limited gains from specialization through the increased production interval when "employing" workers. This is, compared to Adam Smith's discussion of the pin factory where the division of labor causes productivity gains of up to 4,800 %, a very minor gain.[18] Yet these comparatively minimal gains appear to be of sufficient magnitudes for firms to both emerge in the market and last over time.

Running the simulation with zero/low transaction costs produces the same scenario as above: entrepreneurs establish firms and agents willingly join (but tend not to leave) the enterprise and we must therefore reject H_{4B}. The only noticeable difference to above is that the profitability measure for the low transaction cost simulation shows much smaller differences between firms and atomistic agents. While a minor difference, the implications are of great interest: whether in a low or high transaction cost setting, firms emerge with approximately the same frequency, thereby offering no substantial support for transaction cost theory. The absence of transaction costs means agents within firms (both entrepreneurs and "employees") are initially less profitable on average. The situation however quickly changes, presumably as the firm's production experience increases and its per item production cost therefore (marginally) drops.

It is worth noting that firm profitability in both cases is dependent on the size of the market. We do not take into account estimations of market size (supply of inputs, demand of outputs) when agents decide whether to join an entrepreneur, which means the number of firms tends to increase until there are no more (or very few) agents to trade with established firms. At this point, firms (which do not move) no longer engage in trade and therefore make no more profits. However, as firms generally have greater ability (a marginally expanded production interval) they tend to pay less for inputs and get higher

[18] Adam Smith writes that one worker could "make one pin in a day, and certainly could not make twenty" whereas through the division of labor "ten persons... could make among them upwards of forty-eight thousand pins in a day" ([1776] 1976: 8-9).

prices for outputs than atomistic agents (at least the former is in line with Coase's view); this suggests the profitability of firms remains somewhat higher than for atomistic agents throughout the simulation, i.e., until virtually the whole market is integrated in firms or exchanges can take place no longer. Markets with high transaction costs generally reach a standstill sooner than markets with low transaction costs.

The fact that market activity ceases should not be interpreted as a problem, since in the configuration of the simplified model firms may not move and therefore cannot seek trading partners and the consumer is essentially excluded. In real markets, where actors (whether individual or firms) can change locations, utilize communication technology and other means to get in touch with potential trading partners, we would not expect the market to reach such stasis.

The hypothesis testing results are summarized in Table 2 below.

<table>
<tr><th>Hypothesis</th><th>Implementation</th><th>Conclusion</th></tr>
<tr><td rowspan="2">H₁: Atomistic competition is stable</td><td>Unlimited inputs, outputs</td><td>reject</td></tr>
<tr><td>Scarcity</td><td>fail to reject</td></tr>
<tr><td rowspan="3">H₂: High transaction costs (TC) cause integration</td><td>Fixed, universal search cost</td><td>reject</td></tr>
<tr><td>Fixed, varied search cost</td><td>reject</td></tr>
<tr><td>Cost of transacting</td><td>reject</td></tr>
<tr><td>H₃: Impact of TC higher with greater specialization, vice versa</td><td>-</td><td>fail to reject</td></tr>
<tr><td>H_{4A}: High TC and entrepreneurship cause firm emergence</td><td>-</td><td>fail to reject</td></tr>
<tr><td>H_{4B}: Low TC and entrepreneurship do not cause firms</td><td>-</td><td>reject</td></tr>
</table>

Table 2. *Results from hypotheses testing, including their respective implementation*

Conclusions and Discussion

In this simulation of a market characterized by Coasean atomistic competition we show how firms emerge and, eventually, dominate the market landscape. In the analysis, I focused on the emergence of firms and thereby attempted to fill an apparent gap in the literature: economists are primarily interested in the rationale for firms in static models comparing governance structures, while business scholars tend to focus on firms' internal organization or intra-firm interaction and cooperation such as strategic alliances or mergers and acquisitions.

The purpose of the simulation was to study, compare, and contrast the transaction cost argument for establishing firms in the market with an "island of specialization" view based on the idea that firms are structurally different from yet provide a service to markets through their distinct internal structure. The tests show how transaction costs fail to explain the process of emergence but grant firms—when established—higher profitability. Likewise, the entrepreneurial innovation of novel production structures provides not only a basis for establishing firms, but produces sufficient profits to support and reward more extensive divisions of labor.

Granted, the simulation is a simplification and may only to some extent be applicable on the real market. But the results show that there is sufficient reason to question the transaction cost story when considering the emergence of firms, and they also suggest that entrepreneurial innovation and resource specialization may provide a good starting point to explain the integration process in the market. This also raises interesting questions about the overall integration of the market and the observed centralization of market power in very large corporations.

It is difficult to draw general conclusions based on this simplistic model, but the intent was not to explain the real market. Rather, the main contribution of this chapter is the identification that transaction costs, at least when implemented as outlined above, do not seem to cause firms to emerge—indeed, transaction costs seem to have the rather opposite effect on market actors. Furthermore, innovative entrepreneurs can establish firms as a means to bring about novel production structures; this explanation is both independent of, and seems to have greater explanatory power than, transaction costs in terms of the emergence of firms in the market place.

Undoubtedly, more research is necessary to establish and test the generality of this argument. But I believe I have raised important questions in this chapter and provided provocative, interesting, and potentially groundbreaking suggestions for how to answer them.

CONCLUDING DISCUSSION

This dissertation has a single, over-arching contribution: it raises important questions regarding the literature on organization in the market—the firm, specifically—and, especially, the relation and tensions between specialization and transaction costs. Both specialization and transaction costs rely on the inherent heterogeneity in resources and resource constellations in the market, a common ground that is only rarely mentioned. In my view, this link has not been thoroughly investigated, and sometimes seems to be overlooked completely. In fact, the issue of heterogeneity, and therefore specialization, seems to be an issue of tension between the two major transaction cost frameworks: that of Ronald Coase and that of Oliver Williamson. It also suggests potential answers to core questions in the theory of the firm, especially as pertains to firm emergence.

This dissertation assumes specialization and heterogeneity as its starting point and framework. Its three essays adopt slightly different perspectives and aim to raise questions related to the aforementioned fundamental issue in different ways. The first essay adopts specialization as its analytical framework and utilizes this perspective to scrutinize and contrast the transaction cost theories of Coase and Williamson. I use this framework to identify their premises and assumptions, both implied and stated, in order to expose what distinguishes their respective approaches—as well as what unites them. I believe I have shown that while they may appear similar, they espouse different views of the market and what is a firm: to Coase, the firm is identical or similar to the market in terms of resource allocation, whereas Williamson's vertically integrated unit is fundamentally an effect of investments in assets that are specific (if not unique) to the transaction. Undoubtedly, the conclusions from my reading of their works raise many interesting questions for the literature adopting a transaction cost perspective.

In the second essay, I explore the specialization perspective from a point of view of firm emergence. While the first essay scrutinizes the theoretical frameworks of Coase and Williamson primarily on their terms through a primarily static approach, the second essay uses a dynamic approach to identify the mechanisms behind how firms emerge in the market. The purpose of the essay is to uncover how transaction costs relate to the process of integration—and to what extent the transaction cost concept can provide explanations for how firms emerge. The transaction cost analysis is contrasted with an argument based on the division of labor and capital—and especially how specialization, as a process toward intensified heterogeneity, is exploited by imaginative entrepreneurs. In this essay, I wish to show that there is a case to be made for firms as a result of "entrepreneurial specialization" that does not necessarily depend on transaction costs.

While much remains to develop a complete theory of firm emergence, I believe this essay, and the formal model contrasting specialization and transaction costs, comes a long way in raising important questions about the dynamism and objectives of firm creation as well as showing that this is a potentially very interesting field for further research. The essay has two chief contributions: it offers a novel approach in asking the broader question of "how" rather than "why"—and it shows that there is much more to be said about the role of specialization in both the market and within firms.

The third essay provides "empirical" testing of the model developed in the second essay through agent-based modeling, with the purpose of showing to what extent firm emergence can be explained by specialization and transaction costs, respectively. While such simulation models are necessarily simplifications, they can explore the sufficiency of arguments of causality. The simulations in this third essay confirm what was suggested in the second essay: that there is a case to be made for the specialization argument. While the results of these tests in no way provide final answers, they provide preliminary results that are quite interesting. The tests show how transaction costs seem insufficient to explain how firms emerge in a market. Moreover, the specialization argument appears to offer interesting explanations and solutions to problems of incompatibility in the market due to heterogeneity (a weak form of which can be interpreted as transaction costs, at least from the Coasean perspective).

In conclusion, I believe I have demonstrated that resource heterogeneity is an important concept that is far from sufficiently studied. While some research in management and entrepreneurship studies heterogeneity in resources, primarily as a means for firms to develop comparative advantage, the economics literature seems to a large degree to be destitute of this type of analysis. This is unfortunate, since the real world is undoubtedly characterized by rather extensive heterogeneity and economic development seems to proceed to ever more intensive divisions of labor and capital—at a quickening pace.

As I have shown in these essays, heterogeneity strikes at the core of the workings of the market as well as organization. An approach acknowledging the importance and impact of specialization can provide important clues and potentially add both realism and relevance to economic models—as well as improve our understanding for the world. Heterogeneity and specialization open up a vast field of new and interesting research. The purpose of this dissertation was but to indicate one of many possible applications.

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VITA

Per Bylund received his doctoral degree in applied economics from the University of Missouri in 2012. A native of Sweden, he has completed master degrees in political science from Lund University (2005) and informatics from Jönköping International Business School (1999). He pursued his undergraduate studies in business administration at Jönköping International Business School. His research fields are entrepreneurship, organizational theory and management, and the economics of contracts and organizations.