Competition and Cascades in Markets: An Agent-Based Model of Endogenous Mergers

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Abstract

We present an agent-based model of endogenous merger formation in a market with turnover of market participants. We describe the dynamics of the model and identify the conditions under which market competition is sufficiently disrupted to prompt extended periods during which mergers are desirable. We also demonstrate how merger waves can be triggered by industry shocks and firm overconfidence.[1]

Keywords— Cournot competition, agent-based simulation, endogenous mergers, emergent behaviour, merger waves.

JEL Classification Codes— C63, D21, G34.

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1 Introduction

It is well documented that merger activity follows a wave-like pattern, in which a period of high merger activity is followed by a period of low merger activity (Town, 1992; Lipton, 2006; Gugler et al., 2008). However, econometric studies have shown that the pattern of activity exhibited by these waves is both highly country and market dependent (Resende, 1996; Maksimovic et al., 2011). For example, Figure 1 shows how the volume of different types of merger activity in the UK varied between 1987 and 2010[2]. Both outward and inward mergers and acquisitions (M&A) exhibit a somewhat sinusoidal wave pattern. However, UK domestic M&A is better described by a two-phase regime-switching pattern where a persistent period of high merger activity steps abruptly to a persistent period of low merger activity (Gartner and Halbheer, 2009; Resende, 2008).

In attempting to identify the causes of these merger waves, a number of interesting traits have been noted. For instance, the peaks of merger waves approximately coincide with the peaks of stock market booms (Gugler et al., 2008) and some waves can only be seen to affect a subset of markets (Ahern and Harford, 2010). Broadly speaking, the literature provides three potential theory groups for these surges in merger activity: *neoclassical*, *behavioural* and *random*.

Neoclassical theories, such as the Q-Theory of Mergers (Jovanovic and Rousseau, 2002) and the Industry Shocks Theory (Harford, 2005), make use of standard neoclassical assumptions to explain waves. For instance, an industry might receive a shock such as the introduction of a new technology, which enables them to produce goods at a lower cost. This may trigger the profitability of new merger opportunities, resulting in a flurry of merger activity. Aggregate merger waves are then caused when multiple, simultaneous shocks affect a number of industries.

Behavioural theories, such as the Managerial Discretion Theory (Shleifer and Vishny, 2003) and the Overvalued Shares Theory (Rhodes-Kropf et al., 2005), assume non-rational behavioural traits of market players. For instance, an overconfidence in the market may lead to an overvaluation of stock. This may then encourage managers to make more merger bids than usual, either due to the increased perceived value of their own firm or a potential target's.

Despite using similar datasets, empirical investigations have found evidence in support of each of these theories dependent on the filtering techniques applied (Resende, 1999, 2008, 1996; Harford, 2005; Gugler et al., 2008). Lipton (2006) concludes that discrepancies between the findings are

[2]The time series UK merger data was taken from datasets provided by the UK government's Office for National Statistics, www.ons.gov.uk.

caused by the models themselves: 'The overriding problem with these models is that none of them work very well outside the market or timeframe over which they were created'. He argues that this is because there is in fact no single factor that stimulates a wave, but instead a complex combination of economic, social and legal conditions that make mergers more appealing during certain periods. It is this complexity that encourages a bottom-up, agent-based approach to modelling this problem, in which the aggregate effect of individual merger decisions can be considered. We adopt this approach in this paper.

The effect of a single merger on a company is often unpredictable. According to a 2007 study by the Hay Group (Hay Group, 2007), despite motives to the contrary, 91% of corporate mergers and acquisitions fall short of their objectives. Focussing on the British companies, this percentage rises to 97%. It is also found that on average mergers and acquisitions disrupt company operations for over two years, integration takes 19 months, and newly merged businesses are leaderless for two and a half months.

The extended impact of this unpredictability is of particular interest to regulators such as the UK's Competition Commission[3], whose aim is to promote competition, efficiency and stability. Since consolidation may lead to an increase in market efficiency but also systemic risk (Mishkin, 1999; De Nicolo and Kwast, 2002) appropriate regulation of merger activity is an increasingly important focus.

This problem is made more severe by the fact that markets do not exist in isolation; they are connected through a series of complex dependencies such as supply chains, cultural similarities and geographical proximity (see Global Dependency Explorer, 2011[4]). Therefore, dependent on factors such as the strength of the dependencies and the importance of the merging firms, changes to stability caused by mergers in one market can influence the stability of another.

The growing trend towards global integration is increasing the strength and number of these interdependencies and, according to Stephanou (2009), leading to a 'shrinking role of the state in financial systems' as cross-border ownership increases. In the past fifteen years, emerging market cross border M&A deals have nearly quadrupled in number and increased more than five-fold in value. Over the past 40 years, global outward foreign direct investment has gone from roughly $14bn to over $1tr. Therefore, understanding the causes and effects of merger waves has become increasingly important in the regulation of a progressively more global system.

[3] http://www.competition-commission.org.uk/

[4] http://cephea.de/gde

Similarly, understanding the potential cascade effects of mergers enables firms to better evaluate the risk associated with developing inter- and intra-market dependencies (Pergler and Lamarre, 2009). It could also potentially lead to better long-term regulation by providing policy makers with constraints that are less likely to cause disruptive chain effects. Modelling the origin of these effects could also be used later for the testing of new regulations.

One way of doing this is through the construction of dynamic, simulation-based models which can investigate why mergers take place, test how relevant merger behaviour can arise under different theoretical frameworks, and suggest ways of reducing the negative effects of merger waves.

This paper aims to provide the first step towards such a model by constructing a dynamic single-market model in which firms play a game repeatedly where they endogenously target other firms and choose whether or not merge. We identify conditions under which market competition is sufficiently disrupted to prompt extended periods during which mergers become more desirable. We refer to these as 'merger waves'. We also show how merger cascades can be triggered by industry shocks and agent overconfidence.

The rest of this paper is organised as follows: Section 2 presents the foundations for a dynamic agent-based model of endogenous mergers; Section 3 describes the behaviour of the model during simulation identifying conditions in which random turnover of firms generates merger waves, and we demonstrate how the model may be adapted to trigger waves consistent with both neoclassical and behavioural theories; Section 4 concludes.

2 A Dynamic Model of Endogenous Mergers

We consider an agent-based approach to the models of endogenous mergers analysed in Qiu and Zhou (2005) and Neary (2007). We extend these models to explore the dynamic implications of the two-phase game when it is repeated. This allows us to characterise the temporally extended patterns of merger desirability. In the first phase, firms are given the opportunity to merge; in the second, all firms engage in Cournot competition[5]. The outcome of the second phase incentivises the merger behaviour in the first stage.

Production Stage: Cournot competition

In the second phase of the game, firms produce an identical good, at constant marginal cost and no fixed cost, facing a linear inverse demand curve:

$$P = \alpha - Q$$

where P is the market price, α is the market size and Q is total output.

As a result of these assumptions, in a Cournot equilibrium where c_i denotes the marginal cost of firm i and N is the number of operating firms, firms' profits are equal to the square of output:

$$\pi_i^N = (q_i^N)^2 \qquad q_i^N = \frac{\alpha + \sum\limits_{j \in N} c_j}{N+1} - c_i$$

where q_i^N and π_i^N are the (Cournot-Nash) equilibrium levels of quantity and profit respectively. Since demand is linear, outputs are strategic substitutes in Cournot competition. This means that if the number of operating firms decreases due to a merger between any two firms, then output and hence profit of all surviving firms increases. This strategic effect is known as the free-riding effect of mergers (Bernile et al., 2011).

As in Neary (2007), we assume that firms are of two types: n firms produce at marginal cost c and $n^* = N - n$, at marginal cost $c^* < c$. Thus, for $c_i \in \{c, c^*\}$, equilibrium quantities are:

$$q_i = \frac{\alpha + n^* c^* + nc}{n^* + n + 1} - c_i \tag{1}$$

[5]We follow Qiu and Zhou (2005) and Neary (2007) in employing Cournot competition. Bertrand competition would be an alternative option.

We note that a necessary condition for operating firms to produce nonnegative quantities of output is that the market is large enough, i.e., that the market size, α, is such that:

$$\alpha \geq \alpha_0 \equiv n^* c - n^* c^* + c \tag{2}$$

which corresponds to Assumption 1 in Qiu and Zhou (2005). Following Neary (2007), this condition can be equivalently formulated in terms of cost parameters, as follows:

$$c \leq \zeta_0 \alpha + (1 - \zeta_0) c^* \qquad \zeta_0 = \frac{1}{n^* + 1} \leq 1 \tag{3}$$

showing that, in any Cournot equilibrium, profitability requires the marginal cost of less efficient firms, c, to be less than a weighted average of the size of the market, α, and the cost parameter of efficient firms, c^*, where the weights depend on the number of operating efficient firms.

First Phase: Evaluating Merger Profitability

We start by assuming that the pre-production phase of the game consists of a single stage. In this stage, a firm can act as an acquirer or can be a target of a merger offer. Transaction costs are such that only bilateral mergers may be profitable. Also, whenever a merger takes place, one firm ceases to operate. The immediate implication is that, when a merger takes place, the number of operating firms is reduced by one unit. As a result, market competition is reduced and all post-merger operating firms benefit (an instance of the aforementioned *free-riding effect*). This benefit increases with the efficiency of the target of the merger. However, efficient acquirees also demand higher acquisition prices. Consequently, the net effect depends upon the cost configuration of acquirer and acquiree.

The structure we impose on the merger is as follows. An acquirer chooses whether to propose a merger to a given target firm at a given price, or to pass. A target chooses whether to accept or decline the offer. As a target's opportunity cost of accepting a merger's offer is its current profit, the optimal acquisition strategy, when there are N active firms in the market, is to offer target j the acquisition price of π_j^N.

Acquirer i's expected profit from proposing to acquire j, at price π_j^N, in a market with N active firms is denoted by $\pi_{i+\{j\}}^{N-\{j\}} - \pi_j^N$ and, in equilibrium, target j accepts the offer of π_j^N.

As a result, a merger is profitable if it generates positive surplus, i.e., if the post-merger profit of operating firms net of their pre-merger profit is positive:

$$\pi_{i+\{j\}}^{N-\{j\}} - \pi_i^N - \pi_j^N > 0 \tag{4}$$

For example, a merger between an efficient firm i and an inefficient firm j is profitable if:

$$\pi^*(n-1, n^*) - \pi^*(n, n^*) - \pi(n, n^*) > 0$$

where the starred variables refer to efficient firms, i.e., those firm that produce at marginal cost c^*, and $\pi^*(.,.)$ and $\pi(.,.)$ are derived from equation (1).

We refer to *myopic mergers* as those that occur if and whenever their profitability is positive, i.e., for which inequality (5) is necessary and sufficient. Myopic mergers may reflect liquidity constraints on the part of firms (for example, being unable to borrow against future mergers) or can be motivated in terms of explicitly myopic behaviour on the part of the firms involved.

However, as already mentioned, a firm may have a strategic incentive to wait and free-ride on other firms merging, as, by doing this, it may enjoy the benefit of decreased competition without having to pay the acquisition cost. In order to account for these dynamic incentives, we need to extend the pre-production phase to account for multiple stages and explicitly consider dynamically consistent (subgame perfect) choices on the part of firms.

Multiple Stages: Evaluating Merger Profitability

Following closely Neary (2007), we assume that the game consists of n stages of pre-production activity and a final production stage, entirely analogous to what has been previously described. As an example, consider the s'th last stage ($s \leq n$) of pre-production activity and suppose the market composition is (n, n^*). Let $R(s, n, n^*)$ be the minimum reward that a high cost firm requires to agree to a merger and $R^*(s, n, n^*)$ be the expected profit of a low cost firm. Neary (2007) shows that a necessary condition for a strategic acquisition of the inefficient firm by the efficient one, requires that, for each s:

$$R^*(s, n-1, n^*) - R^*(s, n, n^*) - R(s, n, n^*) > 0$$

In fact, Proposition 2 and Proposition 5 in Neary (2007) provide the following useful characterization of the occurrence of myopic and strategic mergers, as a function of the cost parameters:

Neary (2007):

A necessary and sufficient condition for *myopic* mergers to occur is:

$$c > \zeta_1 \alpha + (1 - \zeta_1) c^* \qquad \zeta_1 < \zeta_0 = \frac{1}{n^* + 1} \leq 1 \tag{5}$$

A necessary and sufficient condition for *strategic* mergers to occur is:

$$c > \zeta_2 \alpha + (1 - \zeta_2) c^* \qquad \zeta_2 < \zeta_0 = \frac{1}{n^* + 1} \leq 1 \tag{6}$$

and simulations suggest that $\zeta_2 < \zeta_1$.

It turns out that the inequalities that determine the profitability of mergers in different market configurations are highly non linear in both the cost parameters (c and c^*) and the market size (α). This makes it at best very difficult to understand the behaviour of merger waves, and their potential triggers, analytically. On the other hand, the agent implementation to which we revert next allows us to embed the model in an explicitly dynamic framework.

3 Agent Implementation

Timestep Evaluation

For the dynamic simulation of this model, we consider timestep evaluations (i.e., in each timestep, a fixed series of actions take place).

A market is initialised with N firms, each with a fixed marginal cost c or c^*. Since only active firms (i.e., those producing some positive quantity of goods) should be present at initialisation, we choose parameters c, c^* and α to satisfy inequality (2), or, equivalently, inequality (3).

In addition, at each timestep, there is a random flow of firms that enter or exit the market. New firms are randomly assigned a cost parameter, c or c^*, with equal probability and firms that are no longer able to produce goods exit the market. Also, x random firms are removed, where at each timestep x is drawn with equal probability from $\{0, 1, 2\}$.

Myopic mergers are implemented in the simulation as follows. Within each timestep, the following sequence of events takes place:

1. Each firm i generates a matrix consisting of the payoff achievable in all possible pair-wise mergers with any other firm, j, net of the acquisition cost:

$$\pi_{i+\{j\}}^{N-\{j\}} - \pi_j^N > 0 \quad \forall j$$

2. Each firm i compares the above quantities to the opportunity cost of merging, (i.e., the payoff from not merging), π_i^N.
3. A firm k is randomly selected to act and it chooses to proceed to a merger if and only if this is strictly payoff increasing. If firm k chooses to merge with firm l, then they consolidate in a single firm that produces at the lowest of their pre-merger marginal costs.
4. All firms take part in a Cournot competition.

This is repeated indefinitely.

By construction, at most one merger may occur in any given timestep. Therefore, one variable of interest to us is *merger desirability*: the number of firms who would find it profitable to merge in a particular timestep, if they were given the opportunity to do so. A *wave* of merger desirability may be defined as a sequence of timesteps for which merger desirability is strictly positive.

We explicitly assume that in case of indifference a firm does not proceed to merge. This may promote fewer mergers taking place, but makes the occurrence of merger waves more apparent. From the agent's perspective, it also results in less chance of inadvertently benefitting competitors via the free-riding effect previously identified.

Myopic decision-making refers to the situation in which agents evaluate the profitability of a merger based purely on the immediate payoff that the merger would provide in the next timestep. In terms of the Neary's specification of the model, this implementation corresponds to the following scenario:

Myopic Mergers

(c, c^*) such that inequalities (4) and (5) are satisfied:

$$\zeta_1\alpha + (1-\zeta_1)c^* < c \leq \zeta_0\alpha + (1-\zeta_0)c^* \qquad \zeta_1 < \zeta_0 = \frac{1}{n^*+1} \leq 1$$

We have already established that some mergers that may not be myopically profitable, may nevertheless be appealing to firms who are able to account for the entire stream of future payoffs they may generate. However, since mergers are endogenous in our model, the profitability of any single merger would depend on the profitability of any other feasible merger. This makes it impossible to implement fully strategic mergers in our simulations. We can move one step in that direction by looking at a slightly extended version of our model, where firms evaluate the payoff that a particular merger decision might afford them in both the next competition stage, and the competition after that. In order to do this, some discounted estimate of future behaviour must be made. For the purpose of this simulation, we consider the case in which agents look at most one timestep ahead. In that discounted future, the agent evaluates the most profitable myopic decision that a randomly selected agent would perform and then compares the payoff their merger decision would give them at that future time. We refer to this specification as *pseudo*-strategic and we note that, in terms of the Neary model, this implementation carries an analogy with the following scenario:

Pseudo-Strategic Mergers

(c, c^*) such that inequalities (4) and (6) are satisfied:

$$\zeta_2\alpha + (1-\zeta_2)c^* < c \leq \zeta_0\alpha + (1-\zeta_0)c^* \qquad \zeta_2 < \zeta_0 = \frac{1}{n^*+1} \leq 1$$

in the case where $\zeta_2 < \zeta_1$.

In order to understand what may trigger the occurrence of merger waves, we shall also consider the effect of changes in the *exogenous* parameters that determine the profitability of mergers. Namely, we shall consider the following cases:

Demand Shocks

Shifts in the market size, α, during simulation. We recall that, in our model, the incentive to merge depends on the the size of the market. Ceteris paribus, an increase in α unequivocally raises output and profit via equation (2). However, from inequality (4), the profitability of a merger depends on the expected post merger profit, net of the acquisition price, and all these quantities are affected by shifts in α. Also, a rewriting of inequality (5) in terms of α shows that in order for mergers to occur, α cannot exceed an upper bound, which depends positively on the difference between the marginal costs of inefficient and efficient firms. As a result, the net effect is unclear. In fact, numerical analysis suggest that the effect of α on profitability is non-monotonic and highly non-linear.

Supply Shocks

Changes in the marginal cost of the inefficient firms, c. It is clear that in our model heterogeneity in firms' costs is a necessary condition for mergers to occur. It is also clear that, ceteris paribus, efficient firms produce more, earn more - the more so, the higher is their cost advantage (from equation (2)) - and demand a higher acquisition price. Furthermore, they also benefit relatively more from the decreased competition brought about by a merger. Again, the implied net effect on merger waves is unclear. Inequalities (3), (5) and (6) suggest that the relevant bounds for the market size, α, that trigger merger activity depend on the difference between the marginal costs of production of the inefficient and the efficient firms.

We now provide a discussion with results from simulations of a particular model instance. Due to random number generation in the simulation, the outcome of each simulation is highly path dependent. However, multiple simulation runs enable clear trends to be identified.

Simulation Results

We now provide simulation results of behaviour in a simple market in which all agents behave either myopically or *pseudo*-strategically. We consider the following market:

$$\alpha = 25 \quad c = 6 \quad c^* = 3$$

and suppose that at $t = 0$, $n = n^* = 2$. Every timestep, two firms with random costs assigned from $\{c, c^*\}$ enter the market. In addition to firms that are removed from the market as a consequence of being unable to produce, a maximum of two randomly chosen firms may also be removed. Numerical analysis of inequality (4) suggests that for these values of the parameters, most mergers that are profitable involve an efficient acquirer and an inefficient acquiree.

Unless otherwise stated, these values will remain constant throughout all simulations.

First, consider simulated market behaviour with myopic decision-making agents. Figure 2 shows the number of active firms in a market over time, along with 'merger desirability': the number of firms that would merge if given the opportunity. As can be seen, there are two distinct types of period of behaviour in merger desirability: periods in which a large number of agents wish to merge, and periods in which none do. Sharp spikes in this value indicate the temporary attractiveness of a new member. Of more interest to us, is the appearance of sustained peaks. The regime-switching behaviour of aggregate merger desirability is a consequence of the α limits and the fact that it is more likely for a market to be stable when agent costs are closely clustered.

We also consider simulated market behaviour with pseudo-strategic decision-making agents using discount factor $\delta = 0.5$. We find that there is no significant difference in the aggregate behaviour of myopic and pseudo-strategic decision-making agents[6]. Therefore, for the subsequent simulations we consider agents that behave strategically.

Demand Shocks

We now consider the effect of exogenously generated shifts in the market size α on the emergence of merger waves. This may correspond to behavioural theories of merger waves, such as market optimism. Alternatively, increases in market size correspond to boom periods, and decreases represent recessions.

Figure 3 shows the number of active firms and merger desirability, along with α from a representative simulation run. As can be seen, rather than the constant α as used in previous simulations, α is exogenously made to oscillate about $\alpha = 25$. All other market conditions remain the same.

[6] It is not obvious why this is the case. This question is the subject of future work.

As can be seen, periods of high merger desirability occur for particular α values. Figure 4 shows this more clearly by aggregating data from 100 long-duration (5000 timestep) runs of the model. Here, each dot records the number of firms that want to merge at a point during the sinusoidal wave phase of α from a particular simulation. As can be seen for the parameters chosen here, there is a strong relationship between merger desirability and market size α. For low values of α, mergers are generally undesirable.

Supply Shocks

We now consider the effect of an exogenously generated supply shock caused by shifting the value of c during simulation to c', where $c \geq c' \geq c^*$. This may correspond to a decrease in production costs for certain firms, or to a technological innovation.

Figure 5 shows the effect of shifting $c = 6$ to $c' = 4$ at 500 timesteps. The cost disruption results in a merger wave within the following 100 timesteps.

Figure 6 shows the relationship between the magnitude of the disruption to costs and the properties of the resulting wave. The magnitude of the cost shift for high cost firms is given by: $1 - \frac{c'-c*}{c-c*}$. Therefore, this value is 0 when $c' = c$, 0.5 when $c' = \frac{c-c^*}{2}$, and 1 when $c' = c^*$.

Figure 6a shows the effect that the magnitude of the cost shift has on the proportion of runs that generate merger waves, and Figure 6b shows the average magnitude of merger waves generated. The magnitude of a merger wave is the proportion of firms that want to merge within the 100 timesteps following the initial shock. Since this value is normalised dependent on the total number of firms in the market during a simulation, the maximum value this can take is 100.

As the size of the shock increases, the magnitude of the resulting merger waves decreases, but the likelihood of a wave occuring increases. Therefore, large shocks are more likely to generate merger waves, but these waves are smaller relative to those generated by small shocks.

There is also a clear distinction between waves endogenously generated by the model (i.e. when the magnitude of the cost shift is 0, $c' = c$) and those generated by a supply shock.

4 Summary and Future Work

This paper has presented a simple dynamic model of endogenous merger activity and shown how and why complex aggregate merger behaviour can arise. We have also shown how a single market model is able to generate intermittent sustained periods of merger desirability consistent with theories widely supported in the empirical literature: neoclassical theories reliant on exogenous factors such as industry shocks, behavioural theories reliant on, e.g., overconfidence, and the hypothesis that merger waves are consistent with random fluctuations in market dynamics.

However, there are several limitations to our approach. First, since the model allows only one firm to act during each timestep, there is no opporunity to observe multiple mergers occuring at the same time. Merger waves are nevertheless observable in terms of growth and decline in the *desirability* of mergers. More specifically, we can characterise the model as exhibiting regime-switching behaviour that generates periods of opportunity in which mergers become desirable to a large number of agents, separated by periods during which mergers are not profitable. We believe that such sustained periods of merger desirability may abstractly be considered representative of periods of merger activity.

Second, the influence of market competition on the model's behaviour has not been fully explored. Future work might, for example, analyse whether merger waves occur in an analogous model that features Betrand competition, instead of Cournot competition, and if so whether the pattern of merger waves is similar.

Finally, the model outlined in this paper has defined some of the conditions that can lead to significant changes in the stability of a single isolated market. However, real-world markets do not exist in isolation. Rather, they are capable of mutually influencing one another through a set of complex dependencies mediated by supply chains, cultural similarities and geographical proximity. Consequently, the impact of mergers in one market might be felt in adjacent markets, with individual mergers possibly inciting additional mergers or propagating a merger wave onwards into other markets. This extended effect remains an interesting topic for investigation.

Extending the single market model defined in this paper, we intend to investigate this cascade effect by constructing a multi-market model guided by existing analyses of sector and industry data. Such an extension may help bring a greater understanding of the potential effects of mergers, which could enable firms to better evaluate the risk associated with developing inter- and intra-market dependencies, potentially leading to better long-term regulation by providing policy makers with constraints that are less likely to cause disruptive chain effects, and even be useful later for the testing of new regulations.

References

K. R. Ahern and J. Harford. The importance of industry links in merger waves. American Finance Association Denver Meetings Paper, Ross School of Business, 2010.

G. Bernile, E. Lyandres, and A. Zhdanov. A theory of strategic mergers. *Review of Finance*, 2011. doi: 10.1093/rof/rfr013.

G. De Nicolo and M. L. Kwast. Systemic risk and financial consolidation: Are they related? IMF Working Paper No. 02/55, International Monetary Fund, 2002.

D. L. Gartner and D. Halbheer. Are there waves in merger activity after all? *International Journal of Industrial Organization*, 27:708–718, 2009.

K. Gugler, D. C. Mueller, and M. Weichselbaumer. The determinants of merger waves: An international perspective. ZEW Discussion Paper 08-076, ZEW - Zentrum for Europische Wirtschaftsforschung / Center for European Economic Research, 2008.

J. Harford. What drives merger waves? *Journal of Financial Economics*, 77(3):529–560, 2005.

Hay Group. Dangerous liaisons: M & A - The integration game. White paper, The Hay Group, 2007. `http://www.haygroup.com/`.

B. Jovanovic and P. L. Rousseau. The Q-theory of mergers. NBER Working Paper 8740, National Bureau of Economic Research, Inc, 2002.

M. Lipton. Merger waves in the 19th, 20th and 21st centuries. The Davies Lecture, Osgoode Hall Law School, York University, September 14, 2006.

V. Maksimovic, G. Phillips, and L. Yang. Private and public merger waves. Working paper, University of Maryland, NBER and UCLA, 2011.

F. S. Mishkin. Financial consolidation: Dangers and opportunities. *Journal of Banking & Finance*, 23(2-4):675 – 691, 1999.

J. P. Neary. Cross-border mergers as instruments of comparative advantage. *Review of Economic Studies*, 74(4):1229 – 1257, 2007.

M. Pergler and E. Lamarre. Upgrading your risk assessment for uncertain times. McKinsey Working Papers on Risk Number 9, McKinsey, 2009.

L. D. Qiu and W. Zhou. Merger waves: A model of endogenous mergers. *RAND Journal of Economics*, 38(1):214–226, 2005.

M. Resende. Mergers and acquisitions in the UK: A disaggregated analysis. *Applied Economics Letters*, 3(10):637–40, 1996.

M. Resende. Wave behaviour of mergers and acquisitions in the UK: A sectoral study. *Oxford Bulletin of Economics and Statistics*, 61(1):85–94, 1999.

M. Resende. Mergers and acquisitions waves in the UK: A markov-switching approach. *Applied Financial Economics*, 18(13):1067–1074, 2008.

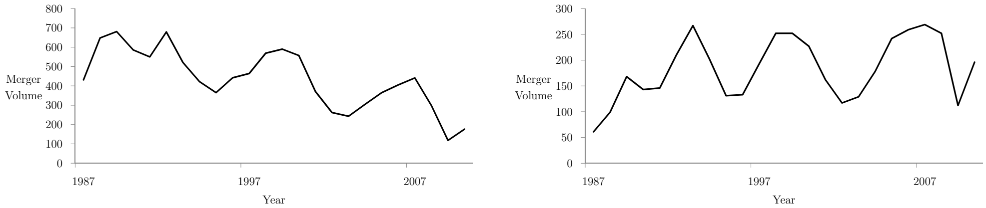
M. Rhodes-Kropf, D. T. Robinson, and S. Viswanathan. Valuation waves and merger activity: The empirical evidence. *Journal of Financial Economics*, 77(3):561–603, 2005.

A. Shleifer and R. W. Vishny. Stock market driven acquisitions. *Journal of Financial Economics*, 70(3):295–311, 2003.

C. Stephanou. Smaller but safer? CrisisResponse Note Number 3, The World Bank Group, 2009.

R. J. Town. Merger waves and the structure of merger and acquisition time-series. *Journal of Applied Econometrics*, 7(S1):S83–S100, 1992.

(a) Domestic UK M&A Activity



(b) Outward UK M&A Activity (c) Inward UK M&A Activity

Figure 1: Contrasting patterns of merger and acquisitions activity in the UK since 1987 as described by M&A volume data provided by the UK government's Office for National Statistics (www.ons.gov.uk). Note that while the volume of both outward and inward M&A actvity is somewhat periodic, domestic M&A is better described by a two-phase regime switching pattern with a step change occuring around 1990.

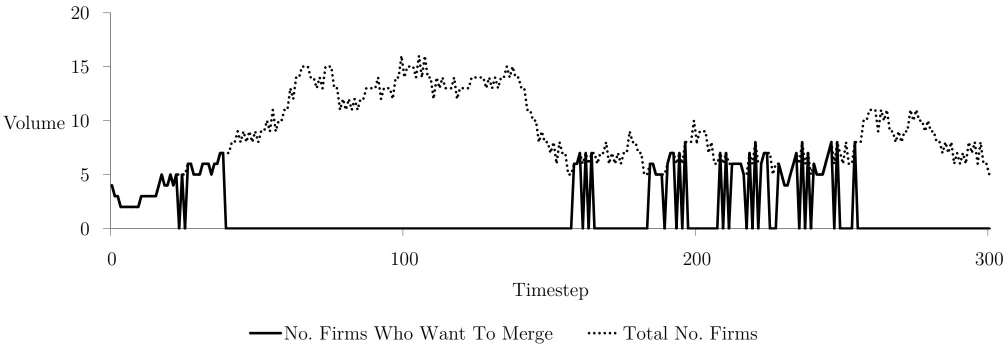


Figure 2: Waves of merger desirability with strategic decision-making agents. Parameters are: $\alpha = 25$, $c = 6$, $c^* = 3$, $\delta = 0.45$, and at $t = 0$ $n = n^* = 2$.

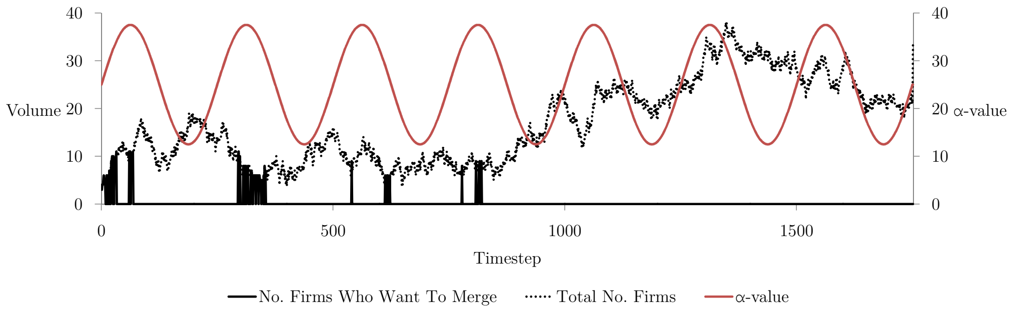


Figure 3: Waves of merger desirability with exogenously determined sinusoidal α and strategic decision-making agents. Parameters are: α follows a sine wave about 25 with period = 250 timesteps and amplitude = $\frac{25}{2}$, $c = 6$, $c^* = 3$, $\delta = 0.45$, and at $t = 0$ $n = n^* = 2$.

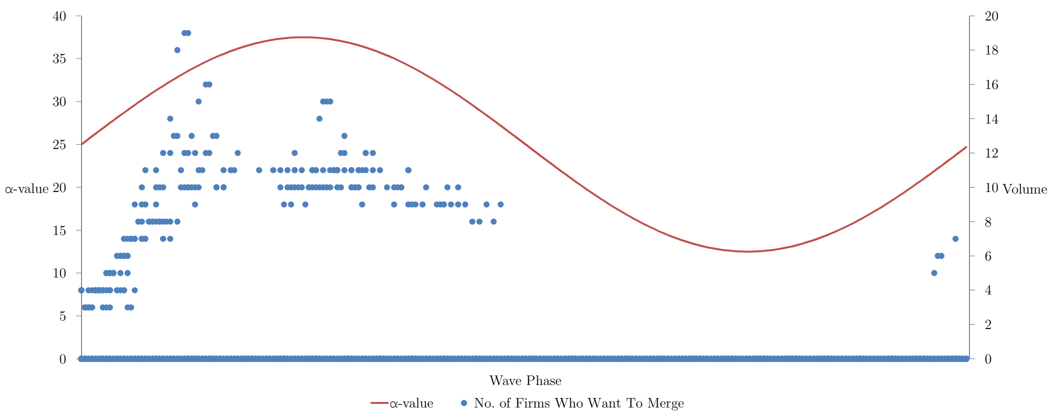


Figure 4: The degree of merger desirability as a function of the phase of the exogenously determined sinusoidal α. Parameters are: α follows a sine wave about 25 with period = 250 timesteps and amplitude = $\frac{25}{2}$, $c = 6$, $c^* = 3$, and at $t = 0$ $n = n^* = 2$. Data is drawn from 100 runs of a 5000-timestep simulation.

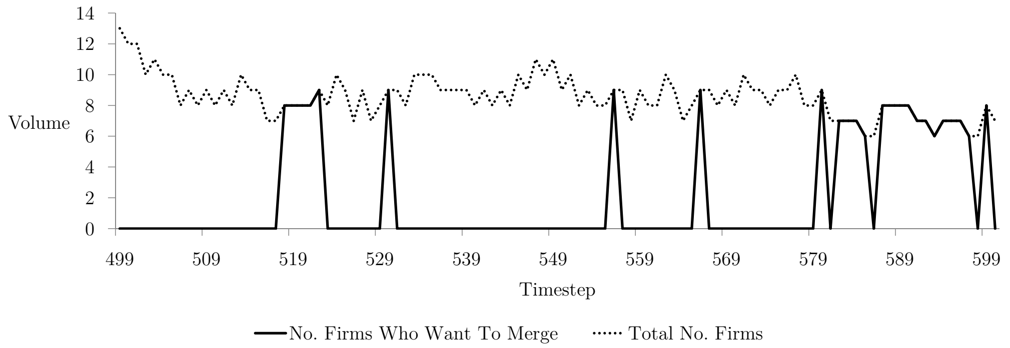
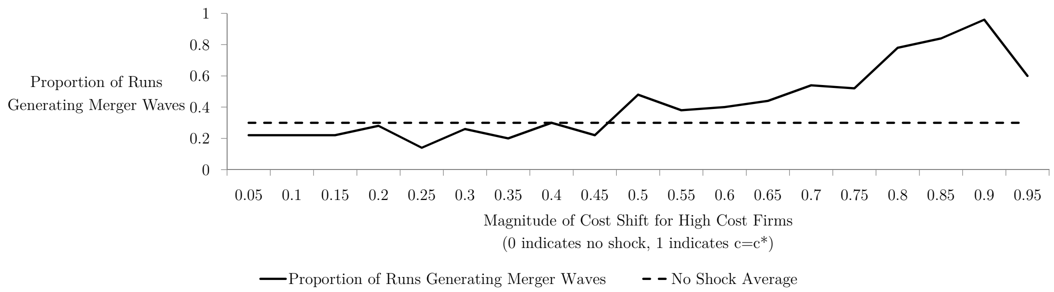
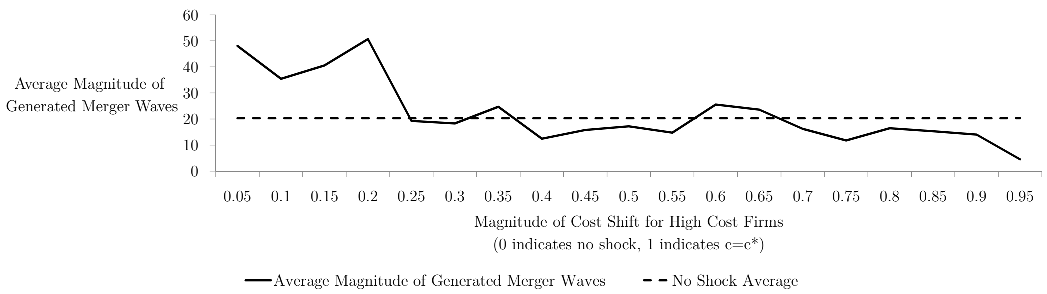


Figure 5: Waves of merger desirability caused by exogenously generated shock to production costs: $c' = c - 2$. The initial parameters are: $\alpha = \alpha_0$, $c = 6$, $c^* = 3$, and at $t = 0$ $n = n^* = 2$.



(a)



(b)

Figure 6: Trend in (a) the likelihood and (b) the extent of merger desirability in the 100 time steps following exogneously generated shocks to production cost. Parameters are: $\alpha = \alpha_0$, c varies relative to c^*, $c^* = 3$, and at $t = 0$ $n = n^* = 2$