Private information and optimal diversification

Beau Page
Draft: September 25, 2009

ABSTRACT

In this paper I extend the Gomes and Livdan (2004) model of optimal diversification to include inefficient resource allocation. Similar to models by Scharfstein and Stein (2000) and Rajan, Servaes, and Zingales (2000), my model predicts that firms will allocate less capital to divisions with good shocks than is optimal in some states. In preliminary results, I calibrate this model and show that even though the diversification discount is explained by self selection, this investment misallocation does have effects on overall welfare. Diversification is optimal for some firms, but does entail the destruction of value.

1. Introduction

Diversification is a choice. Firms which diversify have compared costs and benefits, and decided that the benefits of diversification outweigh the costs. In addition, firms remain conglomerates because the benefits continue to outweigh the costs. Researchers have long been interested in what and how large those costs are, and whether the costs of diversification entail some destruction of firm value.

Past research has been split on whether diversification is value decreasing. Empirical research such as that done by Lang and Stulz (1994) and Berger and Ofek (1995) established that conglomerates are valued less by the market than are a basket of standalone firms in the same industries. The fact that this diversification discount exists leads some researchers to believe that conglomerates must actually be less valuable than standalone firms. If diversification is itself the cause of the discount, and not a symptom of some more basic firm characteristic, then there must be some cost peculiar to diversification.

Two strands of research hypothesize what these peculiar costs might be, both of which build off of the agency cost theory proposed by Jensen and Meckling (1976). The first line of research states that the problem is at the top; the CEO derives some benefit from being the head of a diversified firm. This benefit might be that diversification decreases the CEO's idiosyncratic risk (e.g., May (1995)), or that managers receive some other private benefit such as higher compensation, prestige, or improved career prospects from diversification (e.g., Jensen (1986), Stulz (1990),and Aggarwal and Samwick (2003)).The second line argues that the agency problem infests division management, and manifests itself as the inefficient allocation of firm resources. One of the argued benefits of diversification is that an internal capital market may provide funding for projects that would not be funded as standalone firms (e.g., Stein (1997) and Billet and Mauer (2003)). However, this line of research argues that a division manager may partake in either rent-seeking (Scharfstein and Stein (2000)) or inefficient investment (Rajan, Servaes, and Zingales (2000)) depending on the environment of her division, and that firm headquarters adjusts the allocation of resources between divisions to mitigate the effect of these behaviors. This leads the internal market to be inefficient, and diversification to be value-decreasing. A number of empirical studies have tried to tie the diversification discount to inefficient investment (e.g., Shin and Stulz (1998) and Ahn and Denis (2004)).

On the other side of the divide diversification is seen as a response to numerous internal and external pressures. Diversification, and the diversification discount, cannot be understood without also understanding the costs of not doing it. This literature hypothesizes that a firm diversifies specifically because its prospects as a standalone firm have decreased. In this vein Maksimovic and Phillips (2002) develop a static neoclassical model in which a firm operates in multiple industries if its productivity between the two industries is similar enough. Gomes and Livdan (2004) go a step further and describe a dynamic neoclassical model in which firms can diversify or focus operations across multiple periods in response to productivity shocks; specifically the decision to diversify is based on firm size and the firm-specific shocks respective to each industry. Both models replicate findings from the empirical literature that others accepted as proof of diversification being value-destroying, without assuming any agency costs associated with diversification. In agreement with these models' predictions, empirical studies have shown that firms which choose to diversify often trade at a discount to standalone firms prior to diversification (e.g., Villalonga (1999)), and that the diversification discount goes away if the endogenous selection bias is accounted for (e.g., Campa and Kedia (2002)). In addition, papers such as Whited (2001) and Çolak and Whited (2007) argue that the evidence tying inefficient internal investment to the diversification discount suffers from extensive measurement error and endogeneity.

Both sides in this debate have made strong arguments in favor of their position. In the end, the truth about whether diversification is value-decreasing or not is an empirical question. As such, in this paper I measure the agency cost of diversification by estimating via the simulated method of moments a dynamic, neoclassical model, based on Gomes and Livdan (2004), that includes an agency conflict between headquarters and division management. The source of the conflict in my model is private information endowed to division managers that is not shared by the CEO. Division managers have an incentive to obscure their private information so as to distort resource allocation because they receive utility from division performance in excess of the utility they receive from firm value. In preliminary results reached by calibration, not estimation, I show that this agency problem does effect overall investor and firm welfare, but does not produce the diversification discount. Instead, the diversification discount is an artifact of the determinants of diversification: decreasing returns to scale and cost savings related to operating in multiple industries.

The Gomes and Livdan (2004) model is a good base from which to build my model because of how it captures some of the intuition behind why firms diversify. Early research that found the diversification discount to be value destroying assumed that conglomerates could be valued as a portfolio of standalone firms. Research since then has established that this is not a good description of a conglomerate. Gomes and Livdan (2004) show that a simple neoclassical model can produce an apparent discount for diversified firms which is actually the result of value-maximizing behavior by the firm. Thus their model acts as a control for the endogeneity of the diversification choice.

The major problem with the Gomes and Livdan (2004) model in this context is that it assumes all choices are made optimally and in the best interest of the shareholders. From the stream of literature beginning with Jensen and Meckling (1976), as well as anecdotes such as those shared by Rajan, Servaes, and Zingales (2000), we know that agency problems exist in firms, and that some of these agency problems exist only in diversified firms. Any agency problem which affects diversified firms alone should be seen as an extra cost imposed on conglomerates that will lower value compared to standalone firms. To address this deficiency in the model I add a management layer for the divisions, and endow these managers with private information about their division. This is an appealing setup because we should expect division managers to have more information about their divisions' prospects than the CEO, since they are the CEO's primary source of information about their divisions.

An additional reason I expect division managers to have private information is that CEOs often do not have experience working in all of a company's divisions, and is thus lacking in the correct expertise to make accurate forecasts. In the model division managers use the truthful disclosure of this information to distort the allocation of resources; they do this by only disclosing the information truthfully if it maximizes their utility to do so. Since division managers have incentives to focus on division profits, because of bonuses as well as prestige, they want the CEO to give their division more capital than is optimal. Thus, to incentivize the managers to disclose their private information truthfully, the CEO distorts the resource allocation away from the first best.

I show that this agency problem between the CEO and the division managers leads to firms investing too little in divisions with good private shocks, and too much in divisions with poor private shocks, when there is a disparity in private shocks between the divisions. This is similar to , although not the same as, the investment socialism predicted by Scharfstein and Stein (2000). I also show that the magnitude of the inefficiency can be quite large, given the private information division managers have is large enough. Note that I do not model any agency problems on the part of the CEO with shareholders. I do this because traditional agency issues such as empire building and the free cash flow problem are not specific to diversification, and, as argued by Stein (1997), even given CEOs distort the size of their firms, they still want to maximize firm value given size. Given these arguments, I believe it is the internal conflict, not the external one, which would cause the destruction of value related to diversification.

As stated above, I find that the diversification discount is not related to the agency problem in my model, even though the agency issue does lead to value destruction. The reason for this finding is the dynamic nature of the diversification decision. Firms which are diversified today do not have to be tomorrow. Also, extending the argument beyond the model which only has two industries, a firm operating in three industries today can expand to four or contract to two tomorrow. So, if agency problems are too costly to a firm, then it has a way to deal with it. In addition, firms have control over their size. Since a CEO knows agency conflicts exist with lower managers, he can choose the optimal investment strategy which will maximize value. Investment is attenuated when there is an extra cost associated with being diversified, which means firms stay smaller. In the model, this leads to the market-to-book ratio for diversified firms being larger in a world with agency conflict compared to the first-best world.

The above result calls into question whether the correct metric for estimating any value-destruction caused by diversification is Tobin's q. Çolak and Whited (2007) comment in their conclusion that "it is unlikely that misallocation of capital expenditures is sufficiently important to influence conglomerate value." Given my findings, this may only appear to be true if value is measured by Tobin's q, while not being true when compared to what the first-best world would look like.

The paper proceeds as follows. In section 2 I develop the intuition given above and formalize it into the model. I estimate it in section 3. Then section 4 concludes.

2. Model

Diversified firms choose to be diversified, while focused firms choose not to diversify. This simple fact is important when doing a comparison between the two firm types. Some early empirical work on the diversification discount assumed that a diversified firm could be directly compared to a collection of stand-alone firms from the same industries. This approach is problematic when, as Campa and Kedia (2003) tried to show, the firms which choose to diversify already appear to be discounted compared to focused firms prior to diversification. Without a good control for this selection problem it is difficult to make any definite statements about the existence and/or cause of the diversification discount.

The Gomes and Livdan (2004) model provides a control for this selection problem by modelling diversification as the result of decreasing returns to scale and cost savings related to working in multiple industries. Their work shows that in a neoclassical framework, a profit-maximizing CEO with no agency issues will optimally choose to diversify in some situations, and that in the resulting distribution of firms there appears to be a discount associated with diversification. In other words, in a model in which all agents act optimally, given decreasing returns to scale and cost savings, diversified firms are discounted compared to focused firms because of the environmental factors that drove them to diversify, not because they diversified.

Gomes and Livdan (2004) thus give a good base for understanding the difference between conglomerate and stand-alone firms. However, it is deficient in that we are generally dubious about agents working in the best interests of their principals without costly inducement. In the model I expand the Gomes and Livdan (2004) model to include division managers with private information about their divisions' prospects. This is an appealing setup because a division manager should have more information about her division than the CEO. This is because she is closer to the actual production process, has expertise in her industry, and is the source of information about her division for the CEO. The CEO must rely on the division manager for this information because his job is not production management, and he may have no expertise in the area anyway, especially if he was hired as an outsider. The model hinges on the allocation of resources to each division each period. The CEO wants to allocate resources optimally, but can only do so if he can be sure the division managers are truthfully disclosing their private information. Each division manager has some incentive to distort the resource allocation in her favor, so the CEO and the division managers negotiate over the resource allocation. The resulting allocation is not always optimal, and the question then is how much this contributes to the difference between conglomerates and stand-alone firms.

2.1. Firm environment

Time is discrete and the horizon is infinite. There are two industries in which firms can choose to operate. In any time period t, a firm may choose to focus in one of the industries, in which case the firm's sectoral decision is $s_t \in \{1, 2\}$, or it may operate in both simultaneously, in which case it is diversified and $s_t = 3$. At the beginning of period t the firm realizes its firm-specific shocks ξ_t (with no superscript, this denotes a vector of shocks for both industries), then makes its sectoral decision. I assume that a focused firm faces costs such that it is unable to wholesale switch all of its resources from producing in one industry to the other, instead it may only remain focused in the same industry ($s_t = s_{t-1}$), or diversify into both industries ($s_t = 3$). A firm that enters period t as a diversified firm faces no restrictions to its sectoral decision, but can remain diversified or focus as it sees fit. Formally, the sectoral decision for time t satisfies

$$s_t \in \begin{cases} \{s_{t-1}, 3\}, & s_{t-1} \in \{1, 2\} \\ \{1, 2, 3\}, & s_{t-1} = 3. \end{cases} \tag{1}$$

As mentioned in Gomes and Livdan (2004), this assumption is not necessary for the model to produce diversification endogenously, but it does correspond with actual firm behavior. I could replace it with some form of costly switching, but this would only complicate the model and provide no benefit in answering this paper's question about the value of conglomerates.

A firm operating in industry s at time t produces the final good y_t^s. By assumption, the relative price of goods y_t^1 and y_t^2 is always one. Final good production requires one input: capital or productive capacity, k_t. This is a simplification of the Gomes and Livdan (2004) model, which assumed production required labor as well as capital. The model produces diversification because of the curvature in the production function, and the existence of cost savings related to diversification. Both of these can be modelled without requiring a second input, which would require the estimation of several extra parameters. In addition to the use of capital in producing goods, each firm segment is subject to a technology shock ξ_t^s. The resulting functional form for production is thus

$$y_t^s = \xi_t^s k_t^\alpha, \text{ where } \alpha \in (0, 1). \tag{2}$$

The shocks are division and firm specific. A firm is unable to trade productivity with another firm or within the firm. Technology shocks consist of two components: a public shock z_t^s and a private shock a_t^s. A division's public shock is known by everyone in the firm, while its private shock is known exclusively by the division manager (who is the CEO for a focused firm). Section 2.2 describes the agency conflict which arises from this private information. The public shock is persistent across periods, and follows an AR(1) process in logs

$$\ln z_{t+1}^s = \rho \ln z_t^s + \varepsilon_{t+1}^s, \tag{3}$$

where ε_{t+1}^s is normally distributed around zero with a standard deviation of σ_t^s. For simplicity, the two public shock processes are unrelated, so ε_{t+1}^1 and ε_{t+1}^2 are i.i.d.

The private shocks are either high or low, $\alpha_t^s \in \{\alpha_H, a_L\}$. These shocks are not persistent, but are instead i.i.d. across periods. The probability of a good private shock in any period is $\omega \in (0, 1)$. Also, to simplify the estimation of the model, the high and low values are equidistant from 0, so $a_H = -a_L = \mu$. Since the public shock is known to the CEO, and the firm's final results are also known, the CEO is able to infer the realization of the private shock ex post. However, similar to Hennessy, Livdan and Miranda (2008), I assume that the private shock is unverifiable in court. So even though the information asymmetry is resolved at the end of the period, no enforceable contracts may be written on the shock itself.

Firm capacity follows the simple law of motion

$$k_{t+1} = (1 - \delta) k_t + i_t. \tag{4}$$

δ is the rate of depreciation, and i_t is the amount of investment in capital in period t. New investment at time t, i_t, is deployed and ready for use at the beginning of period $t + 1$.

Upon arriving at time t, a firm has a certain amount of capital k_t, a lagged sectoral decision s_{t-1}, and the previous period's shock realizations ξ_{t-1}. Time t's public shock is then revealed. The firm's first decision is the sectoral choice. If the firm chooses to focus in industry s, then the CEO subsequently learns the private shock a_t^s and production of the industry s final good occurs. If the firm chooses to operate in both industries, then the division managers learn the private shocks. The CEO and the division managers negotiate over the amount of capital the firm will allocate to each division (described in the next section), then the capital is allocated and production of both goods occurs. Finally the CEO chooses the level of investment, i_t, for the next period.

A firm which chooses to focus in industry s in period t generates current period profits

$$\pi(s_t, k_t, z_t, a_t) = (z_t^s + a_t^s) k_t^\alpha - f, \; s_t \in \{1, 2\}, \tag{5}$$

where $f \geq 0$ is a fixed cost of production a firm must pay so as to participate in industry s. A firm which chooses to diversify its production between the two industries instead generates period t profits of

$$\begin{aligned} \pi(3, k_t, z_t, a_t) &= \max_{\theta_t} \left\{ k_t^\alpha \left[\left(z_t^1 + a_t^1 \right) \theta_t^\alpha + \left(z_t^2 + a_t^2 \right) (1 - \theta_t)^\alpha \right] - (2 - \lambda) f \right\} \quad (6) \\ \text{subject to} &: \theta_t \in (0, 1), \\ & \text{Division manger incentive constraints,} \\ & \text{and CEO participation constraint.} \end{aligned}$$

where θ_t is the ratio of firm capital allocated to production in division 1. Since a diversified firm works in two different industries, it pays a larger fixed cost of production. However, since some redundancies can likely be eliminated and other cost savings found, the firm saves $\lambda/2$ of the fixed cost in each division, for a total savings of λf. The incentive constraints that need to be considered in the maximization are the result of the negotiations between the CEO and the division managers. Similar to Gomes and Livdan (2004), this static maximization problem yields an optimal labor decision and production decision each period, given the model parameters and the choice of θ_t. Given the resolution to the incentive problem described in section 2.2, there is also an expected profit maximizing choice of θ_t.

2.2. CEO and division manager negotiations

The model described in the previous section follows the Gomes and Livdan (2004) model very closely. The extension of the model is the contracting game played between the CEO and the division managers when the firm chooses to diversify, or remain diversified. Following the intuition behind Rajan, Servaes, and Zingales (2000) and Scharfstein and Stein (2000), division managers have their own information sets and power bases from which they operate, independent of the CEO. Rajan, Servaes, and Zingales (2000) were concerned with managers propensity to invest in suboptimal projects so as to negate another division's ability to poach resources or returns. Scharfstein and Stein (2000) concern themselves with division managers choosing to invest time in rent-seeking activities as opposed to productive activities, so as to strengthen their negotiating position with the CEO. In this model, a division manager is endowed each period with more information about the technology shock received by her division, a_t^s. The negotiation between the CEO and manager is over the revelation of this information.

To keep the focus of the model on the agency conflict between the CEO and the division managers, I assume the CEO has linear utility in firm value, and there are no agency problems between the CEO and the shareholders. In other words, the CEO's utility is the solution to the Bellman equation

$$\begin{aligned} v(s,k,z,a) &= \max_{s',k'} \left\{ \pi(s',k,z,a) + (1-\delta)k - k' + \frac{1}{1+r} E\left[v(s',k',z',a')\,|z\right] \right\} \qquad (7) \\ & \quad \text{subject to (1).} \end{aligned}$$

Here $r > 0$ is the applicable intertemporal discount rate. Net cash flows (dividends or equity issuance) are the sum of current profits $\pi(\cdot)$ and current investment i, which is described by the law of motion in equation (4). The expectation of future value is taken with the current public shock value as a given, since it is persistent through time. The existence of a solution to (7) is established by proposition 1.

Proposition 1

There exists a unique solution, $v(s, k, z, a)$ *to the Bellman equation described in (7). This solution is increasing in* k*,* z*, and* a*, and continuous in* k *and* z*.*

Proof

Follows directly from the proof of Proposition 1 in Gomes and Livdan (2004), Appendix A. a is not a continuous variable, which is why $v(\cdot)$ is not continuous in a.

Division managers, on the other hand, derive utility from the performance of their division, in addition to the value of the firm. One way to think of this is that division managers receive bonuses based on the performance of the division, and stock options to keep their incentives in line with maximizing firm value. In addition, they may also receive utility from managing a larger division (empire building), and from managing a division with greater profits. The value of the firm may also affect their utility aside from compensation because of the prestige attached to working for a successful firm. In either case, both managing a successful division and working for a successful firm are lead to better career options, which will affect a manager's utility. Since utility comes from more than just compensation, the assumed manager's utility function does not rely directly on monetary compensation. Instead, the model assumes that the division manager's utility function is proportional to a linear, weighted combination of division profits and firm profits. Namely, the utility function for the manager of division s at time t, u_t^s, is

$$u^s(k_t, z_t, a_t) \propto E\left[(z_t^s + a_t^s)(\theta_t^s k_t)^\alpha - \left(1 - \frac{\lambda}{2}\right) f + \frac{1}{\gamma}\pi(3, k_t, z_t, a_t) \,|z_t\right], \tag{8}$$

where $\theta_\tau^s \in (0, 1)$ is the amount of firm capital allocated to division s and time τ, and γ measures the importance of overall firm performance to the manager. The expectation is taken with respect to the other division's private shock. The weighting parameter γ is included inversely because the interesting question is whether or not the agency problem exists. If the weight on firm value goes to infinity, firm value is all that determines a manager's utility, and all private information is automatically shared with the CEO with no need for inducement. However, as the weight goes to zero the agency problem grows. To test if the agency problem exists requires testing that the weight on firm value is infinite, which is not directly possible, but in this setup the test is whether $\gamma = 0$, which is testable. Division managers receive zero utility if a firm is not diversified in period t. I also assume that replacing a division manager is costless if it is voluntary, but that firing a manager causes the firm to bear some non-zero cost.

Once the firm chooses to be diversified in period t, the game proceeds as follows:

1. The CEO offers four possible allocations of capital to the division managers, one for each combination of private shocks: $\theta^{ij}(k_t, z_t) \in (0,1)$, for $i,j \in \{H, L\}$. These allocations are contracts that the CEO cannot renege on.

2. Division managers only have two choices: disclose the true value of the private shock, or disclose the false value of the shock. Each division manager chooses the two contracts corresponding to the value of the private shock she wishes to disclose.

3. The CEO allocates capital according to the disclosures of the division managers, production occurs and payoffs are received.

There is an optimal allocation of resources in this model, $\theta^*(k, z, a)$, which can only be used if a is known for both divisions, and there is a best expected allocation, $\widehat{\theta}(k, z, a)$, which allocates capital optimally given that a is unknown to the CEO. The agency problem occurs because the optimal allocation will not always satisfy the incentive constraints of the division managers. In those cases the CEO can either offer a different allocation than the optimal one so as to entice the division managers into revealing their true private shock, or he can ignore the division managers' shocks and offer the best expected contract, $\widehat{\theta}(k, z)$. He will choose the allocation that maximizes firm value. Proposition 2 establishes the equilibrium.

Proposition 2

1. Assume $a_t^s = a_H$. The manager of division s will truthfully disclose her private shock.

2. Assume $a_t^s = a_L$. The manager of division s will truthfully disclose her private shock *if her incentive constraint* $u^s(k_t, z_t, a_L; \theta_L^s) \geq u^s(k_t, z_t, a_L; \theta_H^s)$ *is satisfied. If this constraint is not satisfied, then the manager of division* s *will choose an allocation corresponding to* a_H.

3. The CEO will offer the efficient set of allocation contracts, $\theta^{ij}(k_t, z_t) = \theta^*\left(k_t, z_t, a_t^{ij}\right)$, *if these contracts satisfy the incentive constraint for both division managers. Both incentive contracts will only be satisfied if* z_1 and z_2 are sufficiently similar

4. If both managers' incentive constraints are not satisfied by the efficient allocation, then the CEO will offer the value maximizing set of allocation contracts from one of three types:

Type 1: $\theta^{ij}(k_t, z_t)$ *such that the incentive constraints are satisfied for both managers,*

Type 2: $\theta^{ij}(k_t, z_t)$ *such that the incentive constraint is satisfied for one manager, or*

Type 3: $\theta^{ij}(k_t, z_t)$ *such that the incentive constraint is not satisfied for either manager. In this case* $\theta^{ij}(k_t, z_t) = \widehat{\theta}(k, z)$.

Whichever type of contract the CEO offers, it will not be efficient.

Proof

See the appendix.

The result of this equilibrium is that resources are allocated inefficiently unless the two divisions have similar public shocks. The model does not always predict investment socialism as defined in earlier literature. Instead, depending on the public shock, there are situations in which a division with a good public productivity shock, relative to the other division, receives more resources than is optimal, while in other situations it receives fewer resources than is optimal. The determinants of the direction of the distortion are the respective private shocks.

This equilibrium results from the assumption in equation (8) that division managers are only concerned with the current period, a result and assumption that may appear to be at odds with my use of a dynamic model. Since all uncertainty about the private shock for period t is resolved at the end of period t, and the only action a division manager has in the model is the disclosure of the private shock, the manager's actions only concern the current period unless there is an agreement with the CEO to make transfers in future periods to diminish the cost of truthful disclosure in the current period. Such an equilibrium is not possible with the current utility function, but would be with one which summed future division profits and used firm value. There are two major reasons why I do not do this. First, the equilibrium in proposition 2 would still be a subgame perfect equilibrium even with a more general utility function. This static equilibrium leads to the largest agency cost, since a CEO would only choose a different, dynamic strategy if the total cost of doing so was weakly lower than following this simpler strategy; this cost argument is important considering my finding that the agency cost contributes little to the diversification discount. Third, solving the model with a more complex strategy would be computationally difficult, making it impossible to perform SMM.

Another concern is that the CEO could propose to pay the division manager for the private information, which would not require the firm to distort its allocation. This will not happen because the private information is not itself contractible. Since a contract written on the private information will not be enforceable in court, the CEO could renege on the promise to pay a bonus if the manager truthfully discloser her information. Using capital allocation acts as a commitment device, which only requires assuming the division manager will have higher utility when division profits are higher.

2.3 Inefficient allocation

The contracting game above takes place in a dynamic model, so the resulting allocation in any state cannot be predicted without solving the model because of the possibility of focusing. In the states in which a firm is diversified, the actual allocation is bounded between the efficient allocation $\theta^*(k, z, a)$ and the best expected contract $\widehat{\theta}(k, z, a)$, given a. This bound occurs because of the definition of the best expected contract; since it is the allocation which maximizes the CEO's utility given he has no information about the private shocks, he would not agree to an even less efficient allocation just to learn the shocks. The CEO is better off not learning the true shocks if doing so requires such an allocation.

Characterizing a general solution as to what the actual allocation will be in any state given diversification requires a lot of algebra, and is not very informative. Of interest, however, is what the most inefficient outcome looks like in comparison to the efficient outcome. If there is no agency problem, or if both managers' incentive constraints are satisfied at the optimal allocation, then the allocation is chosen so that

$$\theta^* (k, z, a) = \frac{(z_1 + a_1)^{\psi}}{(z_1 + a_1)^{\psi} + (z_2 + a_2)^{\psi}}, \tag{9}$$

where $\psi = 1/(1-\alpha)$. On the other hand, if the CEO has no information about the private shocks, and cannot profitably satisfy the managers' incentive constraints, then he chooses the best expected allocation, which is

$$\widehat{\theta} (k, z) = \sum_{i \in [L,H]} \sum_{j \in [L,H]} \theta^* (k, z, a_{ij}), \tag{10}$$

where the z shocks are known. For any set of private shocks, the difference between these two allocations is the maximum misallocation of resources. In expectation this difference is zero.

There are two cases of interest here: when the private shocks are different (one high and one low), and when they are the same. With no loss of generality, assume that, when the private shocks differ, $a_1 > a_2$. Figure 1 shows the efficient and best expected allocation for the case of different private shocks in panel A, the two allocations for the same private shocks in panel B, and the differences for the two cases in panels C and D. This figure assumes $\mu = 5\%$. Figure 2 has the same information, but for an assumed $\mu = 25\%$. The largest differences occur when the public shocks are similar, but not the same, and the private shocks are different. In this type of state the best expected allocation misallocates resources by more than 6% (30% when $\mu = 25\%$). This is substantial inefficiency. In the actual model solution the misallocation may not be this large if the CEO can satisfy the managers' incentive constraints, but the possibility of misallocations of this size do exist with this model.

2.4 Discussion

Comparing the predictions of this model to those of similar models is interesting. Scharfstein and Stein (2000) predict investment socialism: when the productivity of the two divisions diverge sufficiently the CEO diverts investment away from the high productivity division to the low productivity division. Rajan, Servaes, and Zingales (2000) have a more nuanced prediction. Their model predicts that distortion of investment allocation occurs when the resource-weighted investment opportunities diverge; so, for example, a small division with a lot of investment opportunities may actually receive more investment than is optimal, at the expense of other divisions, because of its size. My model has a more complex prediction than Scharfstein and Stein (2000). Like Rajan, Servaes, and Zingales (2000), the distortion of resource allocation differs depending on the situation, and so is not always socialistic. However, resource-weighted opportunities do not have any meaning in my model as currently described; resources are costlessly transferable between divisions, so all that matters is the technology shock. As such the predictions may have a similar character, but the driving forces are substantially different.

One last thing to remember is that diversified firms are not required to remain diversified. So while firms with widely diverging technology shocks are likely to face the largest costs, such a firm can shed the poorly performing division and rid itself of the inefficiency. This possibility is one of the reasons a dynamic model is well-suited for estimating the size of the agency cost; the model allows for firms to make these choices. A model which does not account for this possibility may overstate the cost, since the worst offenders are not given a way out.

3. Estimation

The model described in section 2 does not have a closed form solution. As such, I follow Gomes and Livdan (2004) in solving the model using value function iteration. In addition, I estimate the parameters of the model using SMM. SMM utilizes moments estimated from the data, comparing them to the same moments calculated by the model. The model-calculated moments depend on the structural parameters of the model, and so minimizing the distance between the data and model moments provides consistent estimation of the parameters. Discussion on this method and when it provides consistent estimation is in Hennessy and Whited (2007), appendix B.

3.1. Data

The data I use in estimating moments comes from Standard and Poor's Compustat annual industrial and segments databases, using both the active and the research files. Data are pulled for the years 1998 through 2007. SFAS 131, which altered the reporting of firms' operating segments, was released in June of 1997. Since SFAS 131 required that the segments reported on annual financial statements be broken down by operating segment, for my purposes this is an improvement on the data available before 1998 (a similar sentiment is expressed in Rajan, Servaes, and Zingales (2000)). Also, using only data from the post-SFAS 131 period means that the segment reporting regime is stable over the whole period. From this dataset I remove firms in regulated industries (SIC codes 4000-4999, 6000-6999, or greater than 9000), non-US firms, firms not listed on one of the three major exchanges, and firms that do not have two years of complete data. From the data I calculate Tobin's q as the market-to-book ratio, income (EBITDA) weighted by total firm assets, and investment (change in property, plant, and equipment) weighted by total firm assets. I truncate Tobin's q and income-to-assets at 1% above and below; investment-to-assets I truncate at 1% above, and delete observations with investment-to-assets less than -1.

Compustat segment data is broken down into three categories: geographic segments, business segments, and operating segments. I remove any segment listed as "geographic" since the operative definition of diversification in this paper, and in the previous literature, is diversification in operations, not location. I also remove any segments that do not have a segment id; these are almost all identified as "headquarters," which I do not count as an operating segment. I then match firm-years to a count of the number of operating segments reported in each year. A firm is considered diversified if this count is two or more.

Two of the moments I match come from a regression that relies on segment level operating income and tangible assets. Not all segments in the segments database report this information, so these firms are removed from the sample. One of the other moments I match is the percentage of diversified firms, so in order to do this correctly I correct the standalone part of my dataset by randomly removing firms until the proportion of conglomerate and focused firms matches the proportion from before I removed the diversified firms with missing segment data. The biggest effect this has on my dataset is that the market-to-book ratio for the remaining diversified firms is lower than before.

3.2. Model calibration

Table 1 displays each of the model parameters and their purposes. Following Gomes and Livdan (2004), I set the discount rate, r, equal to 6.5%, the depreciation rate, δ, equal to 10%, and the probability of a good private shock, ω, equal to 50%. The other seven parameters I solve for in the estimation step.

The state space for the model (k, z, a) is discretized to enable simulation. As described in the model, the private shock a can take on one of two values, μ or $-\mu$. The magnitude of μ is one of the parameters I estimate. The public shock, z, follows an AR(1) process in logs described in (3). I estimate the unknown parameters (ρ, σ), which define how persistent the public shock process is, and how variable technology shocks can be. I transform the shock process into a discrete-state Markov process according to the method outlined by Tauchen (1986), using nine points of support for $\ln(z)$ in

$$\left[-4\sigma/\sqrt{1-\rho^2}, 4\sigma/\sqrt{1-\rho^2}\right]. \tag{11}$$

Even though there are only nine points of support in the public shock process, there are also two possible realizations of the private shock for each realization of the public shock, so in total there are 18 points of support for technology shocks. The capital stock, k, takes values in the set

$$\left[\overline{k}, \overline{k}\left(1-\delta\right), \overline{k}\left(1-\delta\right)^{2}, ..., \overline{k}\left(1-\delta\right)^{60}\right], \tag{12}$$

where $\overline{k}$ is defined as the solution to

$$\pi\left(3, \overline{k}, \overline{z}, a_H; \theta^*\right) - \delta\overline{k} = 0, \tag{13}$$

where $\overline{z}$ is a vector of the largest value the public technology shock can take. This value of $\overline{k}$ is chosen because it is not profitable for a firm to choose $k > \overline{k}$.

The simulation method I use is value function iteration. The model is solved in two steps. First I calculate the set of allocation contracts the CEO offers for each $(z_{1,} z_2)$ combination. I do this by initially checking whether offering the efficient allocation will satisfy the managers' incentive constraints. If it does not, then I find the set of contracts for the three situations listed in part five of proposition 2: where one incentive constraint is binding and the other is satisfied, where one binds but the other does not, and the best allocation given that neither constraint is binding. I then find which of these sets of contracts provides the maximum expected profit to the firm, and choose that as the CEO's offer for that (z_1, z_2) pair. After finding all of the allocation contracts, I proceed by guessing a value of the Bellman equation for $v(s, k, z, a)$ (equation (7)), and iterating on the value function until convergence.

Once the model has converged, I simulate a panel of firms to compare to the Compustat sample. The simulation proceeds by generating a random value of z and a for a firm-period, using $v(s, k, z, a)$ and $h(s, k, z, a)$ to generate the data for the firm in that period, then using the Markov-process described above to generate random shocks for the next period. For each firm this process is done for 200 periods, the last ten of which are kept for computing moments, since that is the length of Compustat sample. Dropping the first 190 periods allows each firm to work out of any suboptimal situations caused by the random distribution of starting points. Using this process, I simulate $S = 6$ panels of 20,000 independent and identically distributed firms.[1] I define these variables for comparison between the model and the real data.

$$\begin{aligned} \text{Investment / Book Assets} &= \left[k' - (1-\delta)\,k\right]/k \\ \text{Operating Income / Book Assets} &= \pi\,(s,k,z,a)\,/k \\ \text{Tobin's } q &= v\,(s,k,z,a)\,/k \end{aligned}$$

3.3. Selection of moments

Selecting the right moments is important for estimating a model by SMM. If the chosen moments are not informative about the structural parameters, i.e., the moments are not sensitive to changes in the parameters, then the standard errors will be large and the model may be unidentified.

The public shock process is defined by the structural parameters ρ and σ. Since the assumed process is AR(1), I estimate the autocorrelation of the public shock using the actual autocorrelation of income-to-assets for the pooled sample. The variance of the residual from this regression is directly informative about σ. For the private shock process I need moments that are informative about μ. Informative moments for this parameter are the kurtosis of the autocorrelation residual, and the median of the autocorrelation residual. Kurtosis is informative because the larger μ is, the more a shock is pushed into the tail of the underlying lognormal distribution of the public shock. The median is informative because the underlying distribution is skewed, so if there is more weight pushed to the tails of the distribution, then the median of the residual will be nonzero.

The agency parameter, γ, affects whether resources are allocated efficiently or not. As such, its effect is not first order. To pinpoint the parameter, then, requires a moment that is sensitive to such a second order effect. In the model, resource allocation is a function of

[1] Michaelides and Ng (2000) find that good finite sample performance is observed when the number of simulated firms is approximately ten times the number of firms in the sample.

the shock process, especially the spread between shocks. To capture this in the data, I run a regression of an inter-firm normalized Herfindahl index[2] (the sum of the squared proportions of assets attributed to each segment) on a constant and the sum of squared deviation of segment income-to-assets from the firm mean standardized by the sum of the absolute value of all segments' income-to-assets.[3]

$$Herf_{it} = \beta_0 + \beta_1 IncDev_{it}^2, \tag{14}$$

where i denotes the firm and t is the year. The first order of $IncDev$ is not used because it is zero in all cases. Both β_0 and β_1 are used as moments.

The remaining three parameters are α, f, and λ. The curvature of the production function, because of its connection to decreasing returns to scale, the fixed cost and the cost savings with diversification all are used to produce diversification in the model. To pin these down I use the percentage of firms that are diversified, and the Tobin's q of both focused and diversified firms as moments.

3.4. Estimation results

In this version of the paper I use a calibration of the model, as the results from SMM are still forthcoming. Table 1 lists the values I use for the calibration. I use two different values of μ in solving the model, a low value (0.05) and a high value (0.25), to give an idea how variable the effect of the agency cost is on the diversification discount. In addition, I choose a value for γ such that division managers never choose a separating equilibrium, and CEOs always choose the allocation based on the their expectation of all private shocks. For each value of μ I estimate the model twice, once with the agency cost and once without it. In the cases where there is no agency cost, all capital is allocated efficiently. It is in comparing the

[2] The normalized Herfindahl index is
$H^* = (H - 1/N) / (1 - 1/N)$,
where H is the Herfindahl index, and N is the number of firm segments.

[3] $IncDev_{it} = \sum_{s=1}^{N} \left[\left(Inc_{it}^{s} - \frac{1}{N} \sum_{j=1}^{N} Inc_{it}^{j} \right) / \text{abs} \left(\sum_{j=1}^{N} Inc_{it}^{j} \right) \right]$

Tobin's q between the cases where agency exists and where it does not that the effect on the diversification discount is seen.

Table 2 lists the values of each of the moments as estimated from the real-world data, as well as from each calibration of the model. The calibrated models produce too much diversification, and the market-to-book values are too high for both focused and diversified firms. As in the real data, there is a diversification discount, in that focused firms on average have higher q ratios than do diversified firms, however it is not as drastic in the simulated results as in the real data.

The interesting result here comes from the counterfactuals. As would be expected, there is more diversification when there is no agency cost, since the agency problem makes diversification more expensive. Also, as should be expected because of the Gomes and Livdan (2004) result, the diversification discount does not go away, but how it changes is very interesting. In the low μ case, where the manager's private information is 5%, the spread in q between focused and diversified firms does decrease, but not by very much; removing the agency problem decreases the discount by just over 1.3%. Oddly, average Tobin's q decreases. This occurs because average firm value increases by less than does average firm size, so inefficient allocation does lower value, but its effect on investment and optimal firm size is larger in this case. The last thing to point out is the coefficient β_1 from the regression of the internal Herfindahl index on $IncDev^2$ increases when the agency problem is removed. This is evidence that my private information model leads to investment socialism similar to the Scharfstein and Stein (2000) model, that the capital allocated to divisions with a good shock is lower than optimal while divisions with a poorer shock receive more capital than is optimal. A different way of saying this is that, since a firm should optimally allocate more resources to divisions with better shocks (the Herfindahl index should increase in $IncDev^2$), less sensitivity to $IncDev^2$ is consistent with investment socialism.

A similar story can be seen in the high μ case. Again the amount of diversification increases when the agency problem is removed, and β_1 increases consistent with investment socialism. In this case the cost is large enough that average Tobin's q is lower when the agency cost is included. The real interesting result is that the diversification discount is larger under the no agency problem, optimal investment case than in the case where the agency problem exists. This is driven by the private shock being observable in the no agency case. In the no agency problem case, some firms with diverging opportunities choose to remain focused because they can see that the private shock for the less valuable industry is not favorable to them; in the case where agency problems exist, these same firms still have diverging public shocks, but because they can only act on their expectation of the private shock diversification appears optimal. These firms tend to be those with at least one very good public shock, so they have Tobin's qs that are disproportionately high. In fact, they are so much higher that it pulls up the average Tobin's q for all diversified firms in the agency case, even though these particular firms make a poor decision in diversifying. Similarly, there are firms that find diversification optimal in the full information, no agency case, but prefer to focus when they cannot see the private shocks; these firms have lower Tobin's qs on average, although the disparity is not as large.

As to the question of whether diversification destroys value, the answer is complex. In the $\mu = 5\%$ case diversified firms are more valuable on average when there is an agency problem compared to when there isn't, by 0.10%, while focused firms are less valuable by 0.37%. The unconditional value loss in this case is 0.18%. On the other hand, when $\mu = 25\%$ diversified firms lose 2.21% of value on average when agency problems exist, focused firms lose 1.58% of value, and the unconditional average loss is 2.26%. It is clear that, given this agency problem exists, its is detrimental to overall welfare. However, these value loss numbers do not tell the whole story, since firms are smaller on average when I include the agency problem which mechanically causes the level of firm value to decrease, but has an ambiguous effect on market-to-book. So, this result is consistent with inefficient resource allocation harming society, but not necessarily contributing much to the diversification discount.

4. Conclusion

In this paper I extend the Gomes and Livdan (2004) model to include the possibility of inefficient resource allocation. The mechanism for this misallocation is private information held by division managers combined with division managers having utility that is skewed towards the performance of their own division instead of the performance of the firm as a whole. Resource allocation is done on a period-by-period basis in a static game where the CEO offers different possible allocation contracts to the division managers who then decide whether or not to truthfully disclose their private information by choosing the allocation contract that maximizes their utility. I show that, depending on the magnitude of the division managers' private information, this inefficient allocation can be large, especially when the private information differs between divisions.

In the preliminary calibration and counterfactual results above, the inefficient allocation of resources has a definite effect on overall welfare. However, it is not the cause of the diversification discount. In fact, as measured by comparison of market-to-book ratios, in general diversified firms appear to be more highly valued when this agency problem exists. This is because, when firms know that this cost exists, they change their investment and diversification strategies to accommodate the agency cost. Overall, diversified firms choose to be smaller in response to this agency problem, which counteracts the value decrease. So, papers which try to establish a link between the diversification discount and inefficient investment must contend not only with problems such as self selection and measurement error in Tobin's q, but also the fact that one determinant of q, firm assets, is endogenous.

References

Ahn, S., Denis, D., 2004. Internal capital markets and investment policy: Evidence from corporate spinoffs. Journal of Financial Economics 71, 489-516.

Berger, P., Ofek, E., 1995. Diversification's effect on firm value. Journal of Financial Economics 37, 39-65.

Campa, J., Kedia, S., 2002. Explaining the diversification discount. Journal of Finance 57, 1731-1762.

Çolak, G., Whited, T., 2007. Spin-offs, divestitures, and conglomerate investment. Review of Financial Studies 20, 557-595.

Gomes, J., Livdan, D., 2004. Optimal diversification: Reconciling theory and evidence. Journal of Finance 59, 507-535.

Heckman, J., 1979. Sample selection bias as specification error. Econometrica 47, 153-161.

Hennessy, C., Livdan, D., Miranda, B., 2008. Repeated signaling and firm dynamics. Working paper.

Hennessy, C., Whited, T., 2007. How costly is external financing? Evidence from structural estimation. Journal of Finance 62, 1705-1745.

Lang, L., Stulz, R., 1994. Tobin's q, corporate diversification, and firm performance. Journal of Political Economy 102, 1248-1280.

Michaelides, A., Ng, S., 2000. Estimating the rational expectations model of speculative storage: A Monte Carlo comparison of three simulation estimators. Journal of Econometrics 96, 231-266.

Rajan, R., Servaes, H., Zingales, L., 2000. The cost of diversity: The diversification discount and inefficient investment. Journal of Finance 55, 35-80.

Scharfstein, D., Stein, J., 2000. The dark side of internal capital markets I. Journal of Finance 55, 2537-2564.

Shin, H., Stulz, R., 1998. Are internal capital markets efficient? Quarterly Journal of Economics 113, 531-552.

Stein, J., 1997. Internal capital markets and the competition for corporate resources . Journal of Finance 52, 111-133.

Stein, J., 2003. Agency, information and corporate investment. Handbook of the Economics of Finance, vol. 1A. North-Holland, Amsterdam, pp. 111-165.

Tauchen, G., 1986. Finite state Markov-chain approximations to univariate and vector autoregressions. Economics Letters 20, 177-181.

Whited, T., 2001. Is it inefficient investment that causes the diversification discount? Journal of Finance 56, 1667-1691.

Appendix

Proof of proposition 2

Part 1 of proposition 2 is true because $u^s(k_t, z_t, a_H; \theta_H^s) \geq u^s(k_t, z_t, a_H; \theta_L^s)$. To show this, without loss of generality assume $s = 1$, then $\theta_H^1 = \omega\theta_{HH} + (1-\omega)\theta_{HL}$, and $\theta_L^1 = \omega\theta_{LH} + (1-\omega)\theta_{LL}$. Logically, if division 1 has a high private shock, then the CEO will shift more resources to it; there is no reason why the CEO would prefer to give more resources to a division with a low private shock than one with a high private shock, all else being equal. As a result, $\theta_{HH} \geq \theta_{LH}$ and $\theta_{HL} \geq \theta_{LL}$. Using this in the incentive constraint for the high private shock manager results in the constraint always being satisfied.

Part 2 states that if the incentive constraint is not met, given the set of contracts the CEO offers, then the low type will mimic the high type. No proof is necessary for this.

Part 3 also does not require proof, as the CEO's utility is maximized if he can allocate resources efficiently.

Part 4 is obvious.

Table 1

This table lists each of the structural parameters of the model, its calibration value, and the purpose it fulfills. Note that I use two values of μ, a low value and a high value.

Parameter	Calibration Value	Purpose
r	0.065	Intertemporal discount rate
δ	0.10	Rate of capital depreciation
α	0.55	Output elasticity of capital
ρ	0.69	Persistence of technology shocks
σ	0.39	Variability of technology shocks
f	1.35	Fixed cost
λ	0.07	Savings from being diversified
γ	0.50	Weight of division versus firm profitability
μ	0.05 / 0.25	Magnitude of private shocks
ω	0.50	Probability of a good private shock

Table 2

This table provides estimates of the moments used to estimate the model. The data used in computing the real data moments comes from the Compustat research and active databases, as well as the Compustat segments database. The data is from the period 1998-2007.

The % of diversified firms is defined as the proportion of firms in the dataset with more than one segment over the sample period. Tobin's q is estimated as the market-to-book ratio. Income-over-assets ($IncAssets$) is defined as the ratio of EBITDA to total assets. The autocorrelation related moments come from the AR(1) regression of time t $IncAssets$ for firm i on the $t-1$ $IncAssets$

$$IncAssets_{i,t} = \alpha_i + \rho * IncAssets_{i,t-1} + \varepsilon_{it}, \tag{15}$$

where α_i is a firm fixed effect, and ρ is the autocorrelation. Variance, kurtosis and the median are calculated for ε_{it}.

β_0 and β_1 come from the regression

$$Herf_{it} = \beta_0 + \beta_1 * IncDev_{it}^2 + \zeta_{it}, \tag{16}$$

where $Herf$ is the inter-firm normalized Herfindahl index, and $IncDev^2$ is the squared deviation of segment $IncAssets$ from mean segment $IncAssets$ for the firm at time t.

Panel A contains the estimates assuming $\mu = 0.05$, and panel B contains the estimates assuming $\mu = 0.25$.

Panel A: $\mu = 0.05$			
Moment	From Data	No Agency Cost	With Agency Cost
% Diversified firms	0.4306	0.5628	0.5573
Focused q	2.2764	3.1850	3.1977
Diversified q	1.6497	2.6919	2.6980
Difference in q	−0.6267	−0.4930	−0.4997
Autocorrelation of income	0.2983	0.1758	0.1731
Residual variance of income	0.0072	0.0108	0.0109
Kurtosis of income residual	13.2182	57.0696	56.1933
Median of income residual	0.0006	0.0087	0.0112
β_0	0.2398	0.1120	0.1141
β_1	0.2444	0.6830	0.6354

Table 2 (continued)

Panel B: $\mu = 0.25$			
Moment	From Data	No Agency Cost	With Agency Cost
% Diversified firms	0.4306	0.5797	0.5493
Focused q	2.2764	3.0906	3.0687
Diversified q	1.6497	2.7645	2.7896
Difference in q	−0.6267	−0.3261	−0.2792
Autocorrelation of income	0.2983	0.1362	0.1345
Residual variance of income	0.0072	0.0149	0.0155
Kurtosis of income residual	13.2182	31.3200	30.7224
Median of income residual	0.0006	0.0500	0.0516
β_0	0.2398	0.1181	0.0503
β_1	0.2444	1.0040	0.9497

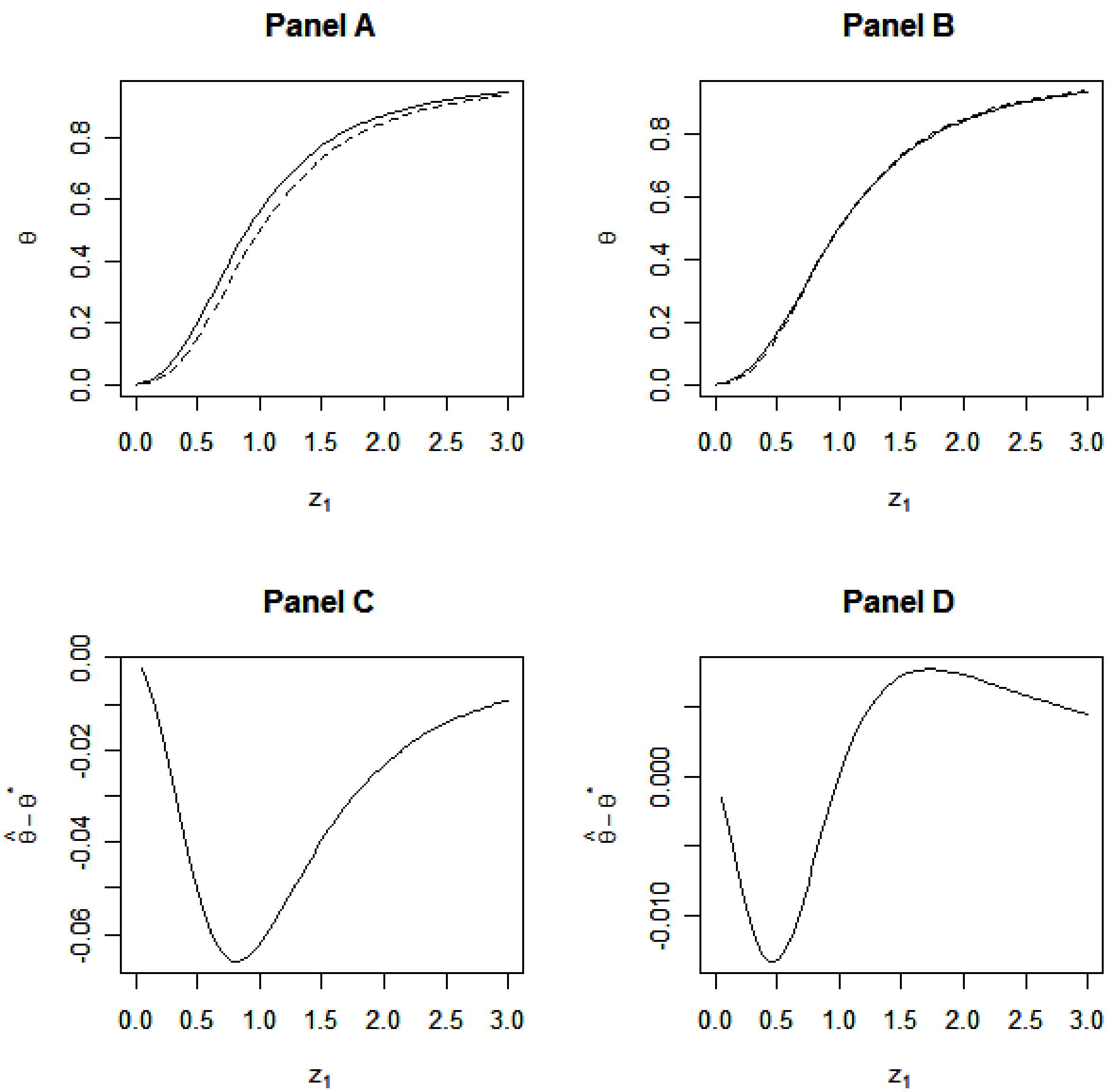

Figure 1: Plots of θ given $z_2 = 1$ and $\mu = 0.05$. Panel A plots the efficient allocation θ^* (the solid line) and the best expected allocation $\widehat{\theta}$ (the dashed line) for the case when $a_1 = a_H$ and $a_2 = a_L$ for values of $z_1 \in [0, 3]$. Panel B plots θ^* and $\widehat{\theta}$ for the case when $a_1 = a_2 = a_H$. Panels C and D plot the difference between θ^* and $\widehat{\theta}$ for the same respective states.

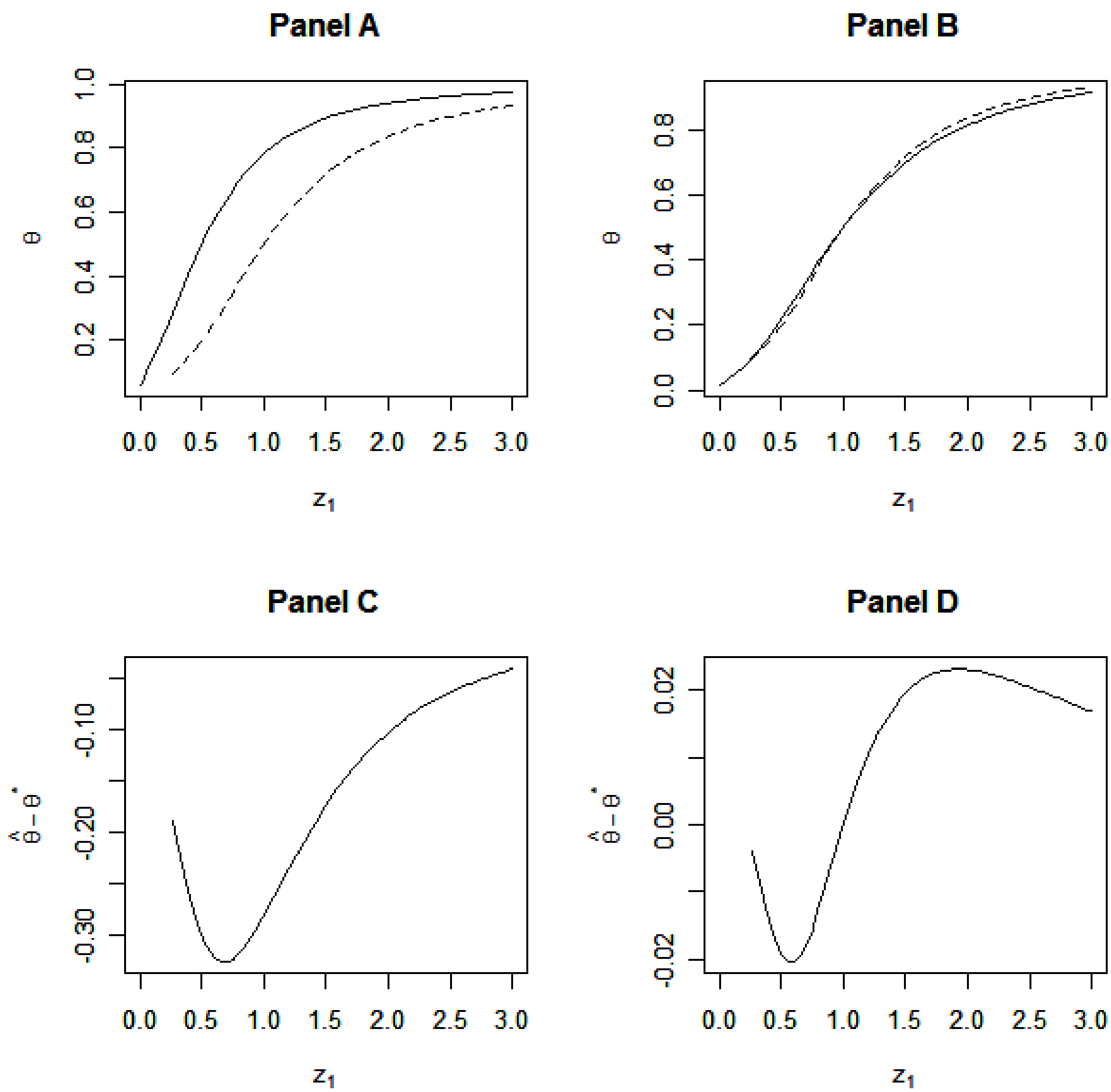

Figure 2: Plots of θ given $z_2 = 1$ and $\mu = 0.25$. Panel A plots the efficient allocation θ^* (the solid line) and the best expected allocation $\widehat{\theta}$ (the dashed line) for the case when $a_1 = a_H$ and $a_2 = a_L$ for values of $z_1 \in [0, 3]$. Panel B plots θ^* and $\widehat{\theta}$ for the case when $a_1 = a_2 = a_H$. Panels C and D plot the difference between θ^* and $\widehat{\theta}$ for the same respective states.