Erasmus Research Institute of Management - ERIM

Does contract complexity limit opportunities?

Vertical organization and flexibility

Enrico Pennings

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Does contract complexity limit opportunities? Vertical organization and flexibility.

Inaugural Lecture

Shortened form of address delivered at the occasion of accepting the appointment
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at the Erasmus School of Economics on behalf of Vereniging Trustfonds EUR
on Friday, September 17, 2010

by

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Samenvatting

De verticale organisatie van productie betreft een reeks maak-of-koop beslissingen van tussenproducten die beïnvloed worden door de moeilijkheidsgraad om contracten af te sluiten met een mogelijke toeleverancier. Als contracten leiden tot hoge transactiekosten, kan een onderneming beslissen om de productie van het tussenproduct verticaal te integreren binnen de onderneming. De moeilijkheidsgraad om contracten af te sluiten kan worden gemeten door de reeks van tussenproducten op te delen in inputs die worden verhandel op een beurs (lage moeilijkheidsgraad), inputs waarvoor referentieprijzen bekend zijn (lage tot matige moeilijkheidsgraad) en andere, vaak relatiespecifieke inputs (matige tot hoge moeilijkheidsgraad). Deze inaugurele rede bespreekt de invloed van contractuele beperkingen op de groeimogelijkheden van een onderneming. De huidige waarde van de groeimogelijkheden is onderdeel van de marktwaarde van een onderneming, die direct gerelateerd is aan de prijs van een aandeel van de onderneming.

Als we de relatie bekijken tussen groeimogelijkheden van een onderneming als deel van de totale waarde van een onderneming en de moeilijkheid om contracten af te sluiten, vinden we dat contractuele beperkingen leiden tot een afnamen van groeimogelijkheden als verticale integratie een probleem is. Waar de marktwaarde van een onderneming, gemiddeld genomen, voor 56% bestaat uit groeimogelijkheden, ligt dit percentage tussen 50% en 53% voor ondernemingen in sectoren waar contracten moeilijk zijn om af te sluiten en waar ook mogelijkheden tot verticale integratie beperkt zijn. Het verschil staat gelijk aan een huidige waarde tussen € 12 miljard en € 24 miljard, alleen al voor Nederlandse beursgenoteerde ondernemingen.

Abstract

The vertical organization of production entails a range of make-or-buy decisions of intermediate goods that are influenced by the difficulty of writing contracts with a potential supplier. When contracting causes high transaction costs, a firm can decide to vertically integrate the production of the intermediate product. Contract complexity can be measured by breaking down the range of inputs into inputs that are traded on an exchange (low contract complexity), inputs for which reference prices exist (low to medium contract complexity) and other, often relationship-specific, inputs (medium to high contract complexity). This inaugural lecture addresses the impact of contract complexity on the growth opportunities of a firm. The present value of growth opportunities are embedded in the market value of a firm, which is a multiple of the firm's stock price.

Examining the relation between the growth opportunities as part of the market value and contract complexity, we find that contract complexity has a negative impact on the growth opportunities of a firm if vertical integration is difficult. Whereas, on average, growth opportunities account for 56% of the market value of a firm, this percentage ranges between 50% and 53% for firms in sectors where contracts are complex and vertical integration is difficult. The difference represents a current market value between € 12 bn and € 24 bn, taking into account only Dutch listed firms.

Content

1. Introduction

Mijnheer de rector magnificus,
Mijnheer de decaan van de Erasmus School of Economics,
Dear family, friends, colleagues, students and other members of the audience.

The title of my talk today is "Does contract complexity limit opportunities? Vertical organization and option value". It combines two streams of literature that have attracted a lot of attention in the field in which I have gratefully accepted my chair: applied industrial organization. These two research themes are the vertical organization of firms and the option value of flexibility. Nobel prizes have been awarded to scientists advancing both streams of literature: to Robert Merton and Myron Scholes in 1997 for their contribution to option theory, and to Oliver Williamson last year for his contribution to the organization of production in the value chain. Both theories also have a wide applicability in business settings. Real options have become popular in explaining the internet bubble, where high prices were paid for stocks of firms without current or past profits, or in explaining why investments in research and development (R&D) pay off even when chances of profitable new products are low. The vertical organization of firms can be explained by make-or-buy decisions in the value chain. The insights are useful in explaining why some inputs are outsourced, often to firms in low-wage countries.

In this talk, I will first briefly outline the principal ideas behind real option valuation and the vertical organization of firms. Then, I will discuss the main proposition that will be derived from integrating both ideas and present an agenda for future research. Given the international nature of this topic, I will use the English language when addressing you.

2. Real options

Let me first briefly outline the concept of real options. The market value of a firm consists of the value of assets in place plus the present value of the growth opportunities of the firm. These growth opportunities are called real options. Real options expert Robert Pindyck of Massachusetts Institute of Technology tells people he has a terrible disease: "I see options everywhere."[1] Companies have all kinds of options, such as to temporarily shut down operations, to buy rivals, or to expand in other markets. "Studying a company's portfolio of options provides insight into its growth prospects and thus its market value."[2]

Real options analysis is a major step beyond static valuation measures such as earnings multiples. One could only compare two companies on the basis of their current earnings if they have the same expected earnings growth. The problem is, they hardly ever do. By applying real options analysis, you value companies by studying the opportunities they have for growth and whether they can turn these opportunities into profitable businesses. Some companies, like the internet start-ups, had negative earnings for a long time, but still had a high market value. Applying earnings multiples would imply then a negative market value instead of a high positive market value. Only a significant real option value can make up this difference.

Zooming in on the growth option component of sectors shows that there are important differences across sectors. In sectors with low uncertainty, such as malt beverages with firms like Heineken, option value is relatively low while in sectors with high uncertainty, such as computer storage devices, option value is considerably higher. One lesson here is that uncertainty can actually be a good thing as uncertainty may yield many profitable opportunities for future growth. When firms organize in such a way that they can avoid losses and take advantage of these profitable opportunities, real options are a substantial part of their market value.

You may ask now how we can avoid losses under adverse circumstances? Major investments can often be postponed while making small investments keeps the option alive. An interesting example is R&D in pharmaceuticals.

[1] Cited from 'Options, options, everywhere', Business Week, June 7, 1999.

[2] See Dixit and Pindyck (1994) for an excellent introduction to real options and Van Bekkum, Pennings and Smit (2009) for the characteristics of real options portfolios.

Prospective drugs are extremely profitable when they are approved and launched on the market. This market launch requires a significant investment in capital and market expenditures. However, very, very few come that far. Early stage testing often involves mice, and they are relatively cheap, certainly when compared to the large market expenses when the product is launched globally. Testing, however, resolves a substantial part of the uncertainty. In the event that some mice die, you certainly know more. So, at a small cost, more information is gathered about the effectiveness and profitability of the drug. This testing is repeated several times. After mice, come men (often students in need of some extra money). When the drug is finally approved, all technical uncertainty is resolved and the decision to spend this significant amount of money on a market launch can be made.[3]

As there are many stages, we have one condition, apart from uncertainty, for options to be valuable. Investing should not be a now-or-never decision. Instead, some time for learning about the value of the investment project is required. The R&D and testing stages clearly provide time for learning about the value of the drug. A stylized two-period example serves to illustrate the difference between a conventional analysis and a real option analysis.

For the first period, we need to decide whether to spend money on R&D or not. In the second period, we decide whether to launch the drug on the market or not. Figure 1 illustrates the decisions. Suppose that the expected value of the drug, after development, is €100mn. Also, the cost of introducing the drug on the market is €100mn. The costs of research and development amount to €5mn. Would you invest in R&D or not? A myopic investor would ignore the uncertainty about the outcome of the R&D process and the flexibility not to invest when the outcome is adverse. He would derive a present value of -€5mn and would decide not to invest.

Suppose our investor also knows that the outcome of R&D can either be a drug that works better than expected (e.g., fewer side effects) and the corresponding value is €150mn, or a drug that works worse than expected and the associated value is €50mn. Both scenarios are equally likely and the expected value is €100mn. The cost of introducing the drug on the market is still €100mn.

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3 See Pennings and Lint (1997) and Lint and Pennings (1998) for contributions on the option value of R&D, and Nichols (1994) for an application of real option valuation at Merck.

In the latter case – the bad scenario – we will not make the investment required to launch the drug. In the good scenario, with the associate value of €150mn, however, we will invest and make a profit of €50mn. The 50% probability of obtaining €50mn in the future will offset the €5mn of investing in R&D now. So, in this case, he will invest. Accounting for the option value of flexibility thus leads to a different decision.

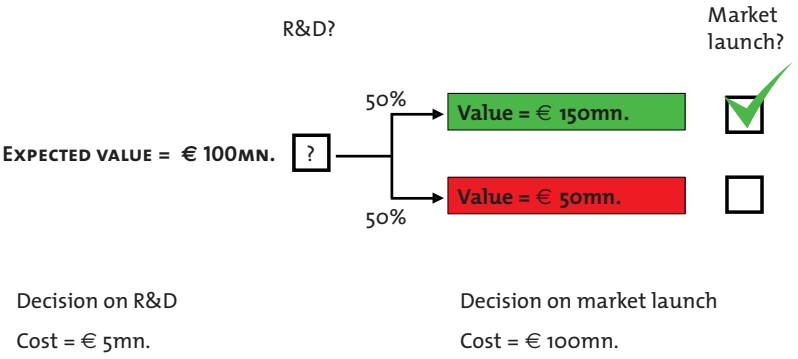


Figure 1: With these project values, should we invest in R&D?

We have established that the flexibility in the investment decision has value. The example can easily demonstrate that a higher uncertainty has a positive impact on option value. Higher uncertainty could be represented by a larger gap between the €150mn and €50mn without changing the mean, e.g. €160mn and €40mn. In case of bad news, you would not invest, so the change from €50mn to €40mn has no impact, but in case of good news, you would invest and gain g10mn more. So, a higher uncertainty has a positive impact on option value.

Sometimes real options have been compared to a navigator, e.g. the TomTom live, and static investment decisions have been likened to the standard TomTom that I have in my car. So, the real options concept can be applied to this talk. Coming from the south of Rotterdam to Erasmus, it tells me the exact route and even how many minutes it will take me to get here. When there is a large traffic jam on the A16 highway in front of the Van Brienenoordbrug, my TomTom tells me to join the queue. However, when I get new information about the traffic conditions during my drive, this information is valuable as I will change my route, avoid the traffic jam and save valuable time.

As Robert Pindyck indicated, the application of real options is certainly not confined to the pharmaceutical industry or car drivers. We observe that option values are also considerable in many other sectors. Let me illustrate learning in an example what seems to be a now-or-never decision.

An oil firm has the opportunity to invest in oil production. However, they can also decide to postpone the investment until the price of oil, and hence the value of the investment project, is higher. So, the investment project competes with itself over time. Also here, investment is not a now-or-never decision unless the price of oil is stable. We have learnt from the past that this is not true. On the contrary, oil price is very volatile and, hence, option value can be substantial. We can illustrate this with a simple example. Suppose the cost of investing in an oil platform is €100mn. The value of the oil field at the moment is €110mn. So, the value of investing right now is €10mn, and immediate investment seems optimal. However, suppose that the oil price is volatile in a way that the value of the field next period can go up to €130mn or down to €90mn, both with equal probability. If it goes down, we clearly won't invest and the value is zero. If it goes up, we will invest and the value is €130mn - €100mn = €30mn. Hence, investing next period gives a value of 50% times €30mn, plus 50% times a value of zero when no investment is made, and is equal to €15mn. However, this €15mn will be obtained one period later. If the discount rate is not too high, the current value of this €15mn is higher than the €10mn obtained when investing immediately. So, when the discount rate is not too high, there is a significant option value of waiting.

3. Vertical organization of firms

The real option examples that I discussed concern decisions of an integrated firm. However, almost no firm is completely vertically integrated, and the decision to invest often involves more than one firm. An example is the large investment decision to run a high speed train. One firm typically invests in the infrastructure (rails) to run the trains while another firm invests in the equipment (trains). Investments are relationship-specific as investments cannot be used outside this relationship. Different timing decisions entail substantial loss for the firm who invests first. A new track with no or slow trains yield no or hardly any profits. This example illustrates that outsourcing a part of the vertical chain may harm option value.

The organization of the vertical chain is the result of make-or-buy decisions for intermediate goods. For each input, a firm determines whether to make the input itself or outsource it to another firm. The general prediction from the work by Williamson (1975) is that standard goods are outsourced and that goods which are more specific to the product are produced in-house. So, a car manufacturer outsources the airbags, but produces the body itself. Nobody buys a car because of the airbags it has, but people do buy one for its unique design.

Standard goods can be outsourced because it is relatively easy to write a contract with the supplier. The supplier does not need to make additional investments in order to be able to supply the intermediate good. This picture changes when an intermediate good becomes more complex and must be tailor-made for the transaction. There is now a possibility that, after making a specific investment, the supplier is confronted with opportunistic behaviour by the firm that outsources. After the supplier makes the specific investment, the outsourcing firm can renegotiate the terms in the contract with the supplier by demanding a lower price for the input good. As the supplier has already made the specific investment, the supplier has his back against the wall. This situation is called hold-up. Also the idea of hold-up can be readily applied to this talk. Suppose, I outsource applause to you in the audience and you invest your precious time in coming to Erasmus in return for this lecture, or perhaps for the drinks afterwards. If I stop now and just serve water afterwards, there are few things that you can (legally) do.

An important condition for the probability of hold-up is the specificity of investments. Investments are specific if they cannot be used for another purpose than the one for which they were intended. The investment in trains is

specific as the trains are tailor-made and cannot be sold to another firm without making a substantial loss. For rails, it is even harder to find an alternative use.

A way to overcome the chances of hold-up is to use vertical integration, meaning to produce the input in-house. Looking across sectors, we find that some sectors produce more of the inputs themselves. We call these sectors more vertically integrated than other sectors. The degree of vertical integration can be measured by the value added of the activities as part of the total sales. A supermarket which buys a tray of beer for g4 and sells it for €5 adds €1 to the total value, and would have an index of 20%. A pharmaceutical firm developing and selling a drug itself would have an index of 100%.

The measure is imperfect though, as profits are part of the value added.[4] Alternatively, we can look at the number of intermediate goods as a measure of the ease of vertically integrating. More intermediate goods mean greater difficulty in doing this. When looking across sectors, we find that the number of intermediate goods ranges from 31 for iron ore mining to 165 intermediate goods for production of motor vehicle parts. We therefore assume that the mining sector is more vertically integrated than is the case for motor vehicle parts.[5]

I have reached the end of the introductory part. Next, I would like to share with you some initial results of the answer to the basic question and outline part of my research agenda for the coming years.

4 See Maddigan (1981) for further discussion on the measurement of vertical integration.

5 This measure is taken from Nunn (2007).

4. Organizational complexity and real option value

As I stated earlier, I intend to examine the relation between contract complexity and real option value. Some important steps have been made in applied industrial organization to measure the complexity of contracts. In a first study, Rauch (1999) has analyzed the complexity of sectors at a very disaggregated level – looking, one could say, almost at the product level – by using input-output tables. These tables show which intermediate goods are used, and in which proportions, to produce the final good. In a subsequent study, Nunn (2007) has analyzed whether these inputs are traded on an exchange or not. If goods are traded on an exchange, contracts are standard and there is no risk of renegotiation of the contract. These products are oils, grains, etc. So, for the food industry, inputs are fairly standard, and we expect no contract complexities.

We will use two measures of contract complexity. The first measure of complexity ranges from 0 where all inputs are traded on an exchange to 1 where none of the inputs are traded on an exchange. The average value of this measure of contract complexity is 87%. However, inputs can be 'standard', even if they are not traded on an exchange, but for which reference prices, e.g. in a catalogue, do exist. If we assume no contractual complexities when inputs are reference priced or traded on an exchange, we can construct a second measure of complexity, also ranging from 0 to 1. The average value of this second measure of complexity is 51%.

The two measures of contract complexity are illustrated in Figure 2. The ten squares represent intermediate goods that are required to produce a certain final good. For this example, we assume that all intermediate goods are used in the same proportion. These intermediate goods are either traded on an exchange (green colour), reference priced (blue colour), or specific (red colour). The first measure of complexity sums up the proportion of red and blue squares (80%) while the second measure of complexity sums up the red squares only (50%).

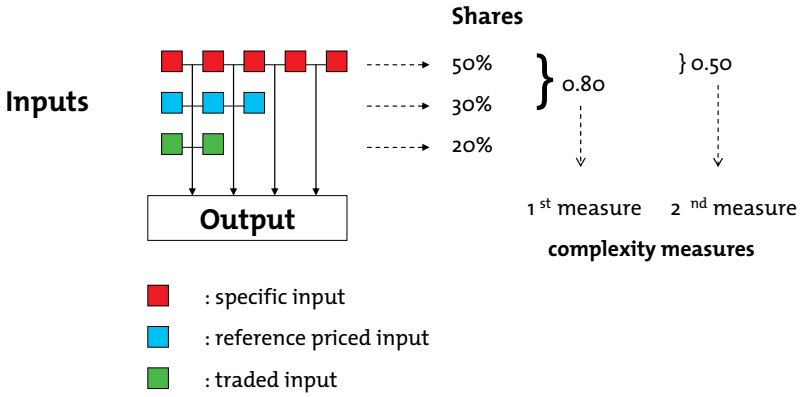


Figure 2: Measurement of contract complexity

With the work of Nunn, we have two measures for the difficulty of writing contracts in the value chain and can use these measures to examine whether there is an impact of these measures on the option value. Our measure of option value is the present value of growth opportunities as a fraction of total market value. We find that option value, averaged over all firms, accounts for 56% of the total market value of a firm over the past 15 years.

To see whether there is a difference between firms in sectors with high or low contract complexity, we split up the total sample in sectors in which contracts are relatively difficult to write and sectors in which this is not difficult. Note that we have two measures of contract complexity. For the first measure, we find that sectors with complex contracts have an average percentage of option value that is 4 points higher and, for the second measure of contract complexity, this percentage of option value is 1 point higher. So, at first sight, complexity increases option value.

However, contract complexity can correlate with many variables that have an impact on option value, for example product complexity or research and development expenditures. A more complex product is more difficult to imitate and gives a wide range of new applications and growth opportunities. The omitted variables may cause a positive effect of product complexity on option value.

Furthermore, if hold-up for some input is a serious threat to option value, a firm may produce this input itself and thus vertically integrate this part, while outsourcing less crucial parts. In other words, firm can undertake strategic actions so as to prevent any negative effect on option value.

So, we need to go a few steps further. As a first step, we control for several variables that explain option value. Think of expenditures on research and development, uncertainty, intangible assets, size, debt of firms and industry-specific effects.[6] We now find a different picture. Accounting for these variables, the first measure of complexity now lowers the percentage of option value 1.2 points on average, while the second complexity measure lowers the percentage of option value by 4.4 points. We are talking about billions of Euros.

As a second step, we make a distinction between sectors in which vertical integration is relatively easy and sectors for which this is not the case.[7] If vertical integration is easy for a firm, we hypothesize that contract complexity has no negative effect on option value. So, if a firm can run a railway, build rails and also produce trains, product complexity has no significant effect. But, if vertical integration is difficult, complexity will have a negative effect on option value. This hypothesis can be tested by using a proxy for the ease of vertical integration, which we have discussed before and related to the number of inputs.

We split the sample in sectors in which vertical integration is easy and those in which it is difficult. For the first measure of contract complexity, we find that option value in sectors where contracts are complex, but vertical integration is easy, is roughly the same as in sectors where contracts are not complex. However, the percentage of option value in sectors in which contracts are complex and vertical integration is difficult is on average 3.5 points lower. For the second measure of complexity, this number increases to 7.2 points.

Figure 3 summarizes the main results and shows the percentage points of the present value of growth opportunities as part of the total market value in

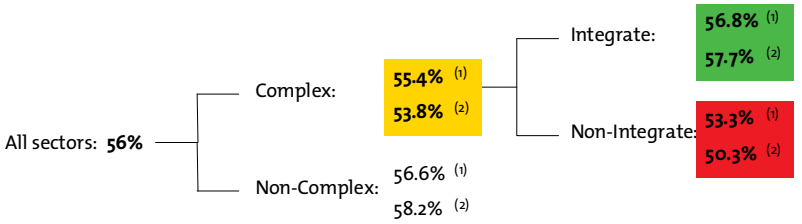
[6] Data over the years 1992-2006 is taken from Worldscope. For a similar analysis, see De Andres-Alsonso, Azofra-Palenzuela and De La Fuenta-Herrero (2005).

[7] This distinction is based on the number of inputs to produce the final good, as discussed in Nunn (2007). As an alternative, we used the results in a recent study on vertical integration by Acemoglu, Johnson and Mitton (2009) in order to distinguish integrated and non-integrated sectors. The results obtained are roughly comparable to the results reported in this study.

sectors with different contractual complexity. Whereas, on average, growth opportunities account for 56% of the market value of a firm, this percentage ranges between 50% and 53% for firms in sectors where contracts are complex and vertical integration is difficult. The difference represents a market value of between €12bn and €24bn just for Dutch listed firms.

So, coming back to the question posed in the title: 'Does contract complexity limit opportunities?', I answer this question as a typical economist: it depends. Yes, if we cannot vertically integrate. No, if we can vertically integrate.[8]

Present value of growth opportunities / Market value



(1) : Complexity measure 1
(2) : Complexity measure 2

Figure 3: Main results

[8] For detailed results, see Pennings (2010).

5. Opportunities for further research

The results I showed are preliminary and open up many opportunities for future research. These opportunities are real options as they are investments in precious research time with a highly uncertain payoff. Moreover, the topic of today sources from many inputs of the economics and management literature. From what we have learnt from this lecture, we know that the value of these opportunities will be substantially lower when we cannot vertically integrate. Fortunately, we can and do. ERIM and its research programs successfully integrate research from Erasmus School of Economics and Rotterdam School of Management. As teaching is not subject to an uncertain payoff, a similar integration for teaching seems unnecessary from this lecture's point of view. This type of application to examining organizational forms is one direction for future research.

From a more theoretical point of view, results on hold-up have shown that there is an incentive to under-invest in relationship-specific assets. If a supplier runs the risk that the outsourcing firm will not buy, she will be reluctant to invest and will make the product less specific. The question is whether this result is still true in a dynamic setting where firms have an option value to wait. A supplier, knowing the probability of hold-up, can wait for better market circumstances, just like the oil firm in the second real option example, and invest when the situation is more favourable. As a consequence, the required return on investment is fixed and hence under-investment need not occur. When the chance of hold-up is high, a firm will simply wait longer until it gets the required return on investment. This would indeed imply that a higher chance of hold-up leads to a lower option value. However, it also implies that the spells between investments are longer and that the level of investment is unaffected when the risk of hold-up increases. This implication is extremely interesting for empirical research as it would go against current thinking.

A third avenue for further research would be to take a closer look at product complexity and vertical integration. Though we have data at the firm level and over a large time span, the measure for vertical integration we use, as well as the measure for product complexity, is fixed over time and fixed across firms in the same sector. Constructing time-varying variables at the firm level would increase the number of observations considerably and would enable the estimation of the impact at the firm level. As a result, we could explain the growth opportunities of a firm, and its market value, much better. This would be extremely helpful when making decisions on mergers, acquisitions, privatization and other strategic business decisions.

Although this research agenda is only a part of a much broader agenda of our research group, I hope to have convinced you that we are working in the forefront of applied industrial organization where decisions of firms are increasingly considered as dynamic and where the proliferation of panel data will facilitate the understanding and analysis of these decisions.

6. Words of thanks

At the end of this inaugural address, I would like to thank all those who contributed to my appointment at Erasmus and who helped me along on the road that brought me here.

Hooggeleerde Franses, beste Philip Hans,

als docent econometrie liet je zien hoe mooi en relevant wetenschappelijk onderzoek kan zijn en ik was er trots op dat je mijn scriptieverdediging wilde voorzitten. Graag wil ik je bedanken voor het in mij gestelde vertrouwen. Ik zal er alles aan doen om de mij toevertrouwde taak zo goed mogelijk te vervullen.

Hooggeleerde Veenman, beste Justus,

De capaciteitsgroep toegepaste economie is een prachtige club geworden met een mooie toekomst. Hartelijk dank voor je inzet voor de capaciteitsgroep en het vertrouwen in mij en mijn onderzoeksgroep.

Hooggeleerde Commandeur, beste Harry,

Het telefoontje naar Milaan kwam als een verrassing. Spijt van mijn terugkeer naar Erasmus heb ik geen seconde gehad. Ik geniet nog elke dag als ik naar mijn whiteboard vol met 2x2-matrices en pijltjes kijk. Hartelijk dank voor je input en vertrouwen.

Hooggeleerde Sleuwaegen, beste Leo,

Een afleiding of regressieresultaat, hoe mooi ook, zegt niets als je de inhoud en betekenis van het resultaat niet begrijpt. Ik denk dat dit je belangrijkste les was voor mij bij mijn promotie. Daarna volgden prachtige jaren samen in Leuven en andere delen van de wereld. Dank voor alles.

Distinguished Colleagues in the department of Applied Economics at Erasmus University, co-authors and PhD students,

It's a joy to work with all of you. Thank you all for creating a nice working place that inspires me time and time again. In particular, I would like to thank Sjoerd van Bekkum for calculating the option values used in this lecture.

Distinguished Students,

Your valuable feedback keeps me sharp. It's a blessing to see so much talent and progress. You are the future.

Lieve ma, pa, familie en vrienden, querida familia,

Vaak moesten jullie een eind reizen om elkaar te zien. Hartelijk dank voor jullie komst vandaag en jullie steun over al die jaren. Muchas gracias por venir de lejos y apoyarme en todo lo que hago.

Querido Rick,

Paso los mejores momentos del día contigo. Tu energía, amor y comprensión han contribuido mucho al resultado de hoy. Me considero afortunado por estar a tu lado.

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