ASSET PRICE BUBBLES, OVERINVESTMENT AND THE UNDER PRICING OF RISK IN SYSTEMICALLY IMPORTANT REAL SECTORS

by

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Introduction

A theoretical framework and the justification for the study of systemically important real sectors (SIRS) was introduced by Crean and Milne (2015). In the time period of 1995-2009 a collection of SIRS sectors: media, automotive, and real estate caused 59 percent of all loans loss from banks. From January 2008 to December 2009 four other SIRS industries: printing and publishing, other media (such as film), chemical, and commercial real estate caused 68 percent of all loan losses. In addition to these facts Crean and Milne (2015) introduce a common structure of SIRS firms and identifiable features.

These common features are: i) SIRS firms have very high asset to revenue levels, meaning it takes a high amounts of capital expenditure to produce revenue. ii) They have high financial leverage since they commonly need to borrow, leveraging themselves in order to purchase the assets required for production. iii) They have low marginal costs, since the bulk of the total cost comes from initial investment in capacity at the beginning of the production phase. iv) They have strong competition and are usually unable to exhibit market power. v) Future cash flows are uncertain to the company since the state of demand and government policies are unknown due to the large lead-time in production. Lastly, they tend to borrow high amounts from banks. This last fact agrees with high leverage, since firms must buy property, plants, equipment, etc. prior to any possible revenue. Hence, they must finance themselves through loans.

When these factors combine it makes for potentially dangerous scenarios. For example, imagine a firm who borrows heavily from a bank in order to buy land

and build a factory. They must put the factory and land up as collateral for the bank to approve the loan. Once the factory is built and production begins, strong competition in the sector forces prices to converge to marginal cost plus the cost of capital. At this point the firm should be able to repay the loan and make a profit in the sector, since the high start up costs acts as a barrier to entry.

However, if there is a downturn in demand either while the factory is being built or shortly after production has begun, it can have harsh effects on the sector. Since the production capacity is limited, this causes prices to fall. In an extreme case price can fall below marginal cost, if there are large storage costs of product inventory. Then the firm is no longer able to service the loans and is forced to declare bankruptcy.

This scenario has repeated itself many times throughout history. Many of these crashes have shared the same characteristics: i) very high investment in capacity, ii) sporadic high volatility of returns, iii) sectors that operate on high amounts of leverage, and iv) the sector seems stable until there is a collapse in demand. This collapse causes chronic overcapacity and the near impossibility of the sector to pay off its debt. With the common characteristics of both crash and sectors one would think we would be able to identify and prevent these crises from occurring.

With the high stakes of these crises it is important to identify and monitor these sectors and possible collapses. A list of these sectors includes mining, the oil sands, housing markets, construction (both residential and commercial), chemical plants, and the automotive sector. These sectors can falter when the demand for their goods suddenly falls. Both current and historic examples demonstrate these effects.

One need only look to the subprime mortgage crisis of 2008 to see the effects of a sudden drop in housing demand on the real estate market. This crisis was led by overinvestment in new housing projects and the high leverage levels of homeowners through the formation of subprime mortgages. This caused massive damage to the economy.

Other crises have occurred that are attributed to the SIRSs. The savings and loan crisis in the 1980's and the real estate boom of the 1920's were related to the housings SIRS. Crean and Milne (2015) also describe a SIRS component in the copper bubble in the late 1890's to 1907. One can easily observe the striking similarities between these crises and those currently emerging in the commodities market.

Similarly, the current drop in oil prices caused many oil sands projects to be put on hold and a stop in production on some completed projects. While this did not cause a complete crash in the sector (as in the housing example above), note how the fall in oil prices occurred as a surprise, and induced overcapacity in the form of idle mines. Thus, the effect of a major fall in oil prices was likely not taken into account, when many of the decisions surrounding oil sand investment levels were made.

A similar experience occurred with the iron ore mining industry. With iron ore prices falling rapidly this year due to a drastic fall in demand from China, the profitability of iron ore mines is now in question. With lower demand and falling prices it is simple to think of scenarios where this leads to excess capacity and iron ore companies struggling to pay their loans. With prices falling for a wide range of commodities this struggle may be repeated in many sectors.

These crises emerge due to the nature of the SIRSs large lead-time on production, and asset prices rising above their fundamental values. This is an occurrence called an asset price bubble. These bubbles occur when agents disagree about the asset's fundamental value, causing speculative trading. This event coincides with high levels of overinvestment in the sectors, as well as, the underpricing of default risk. This underpricing is a natural result when agents underestimate the probability of a collapse in demand.

To exacerbate this problem many of the policy and banking regulations are focused on the use of market data. This proves to be an issue if data for severe downturns is not included in the sample; thus these techniques underestimate the possibility of their occurrence. This fact and the ones listed above indicate a need for better understanding, forecasting techniques and, policy choices of these events.

It is clear from these crises recurrence that we have not learned from the overinvestment and default losses of the past. In this paper I give an exposition of the Crean and Milne (2015) SIRS theoretical model, extend the model to incorporate divergent expectations (Xiong(2013)), and demonstrate how this model can be used to explain overinvestment and underpricing of risk. Both simple theoretical models as well as numerical examples are provided to offer reader insight.

Literature Survey

Price bubbles occur when the price of an asset rises above its fundamental value. When these bubbles occur they have disastrous consequences for an economy. These range from overinvestment in industries, to bankruptcies and contagion issues that can cripple an economy. Due to the severe nature of these consequences a large and ongoing body of research has been dedicated to the field. See Brunnermeier and Oehmke (2012) for a survey of the literature.

Bubbles have occurred many times throughout history and are commonly described by a few stylized facts. First, bubbles are commonly associated with technological innovation, which investors have little experience analyzing. Secondly, they coincide with an intense increase in financial trading volume. Thirdly, bubbles are vulnerable to increases in the supply/float of the asset. Finally, bubbles may burst with little warning[1].

These stylized facts originated from the study of historic bubble episodes and are contemplated during the construction of models. Examples of these historic bubble events include: The Dutch Tulipmania, The South Seas Bubble, The Roaring 20's, The Dot Com Bubble, The Housing Bubble[2], The Chinese Warrants Bubble[3], and the Chinese A and B shares event[4]. This brief literature review will describe some theoretical models and empirical results, as well as, how these results relate to the modeling of SIRS industries.

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[1] See Xiong (2013) and Scheinkman (2013).
[2] See Xiong (2013).
[3] See Xiong and Yu (2011).
[4] See Mei, Scheinkman and Xiong (2009).

Miller (1977) develops a model with risk neutral agents having heterogeneous beliefs. Optimists can exert pricing power, increasing the price of the asset, as long as there is a sufficient number of optimists or, a small enough float. This insures the marginal buyer (the most pessimistic agent who still buys the asset) is an optimist. A necessary element of this model are short sale constraints, which prevent the pessimist from exerting equal pricing power to lower the price.

Harrison and Kreps (1978) take this argument further and started a discussion on the speculative behavior of asset prices. They show with risk neutral agents, heterogeneous belief structures, and short sale constraints, that the upward pricing power of the optimist was driven by the resale value of the asset. This clearly showed that agents would be willing to pay more than the perceived worth of the asset, due to the return they speculated they could earn from selling to a more optimistic buyer in the future. This created a clear model where asset prices rose above the fundamental value.

It is worth discussing the source of these heterogeneous beliefs. In a short literature review on disagreement and learning Carlin, Longstaff and Matoba (2014) state heterogonous beliefs can stem from heterogeneous priors, differential interpretation of signals, and different updating strategies. I do not discuss why agents have heterogeneous beliefs. I instead point readers to an extremely thorough and important literature review on the subject by Hirshleifer (2001).

There has been a large and growing body of empirical work on bubbles and the analysis of the stylized facts. This however remains an unfinished area of research, with much left to learn in forecasting the formation and bursting of bubble events. I direct readers to my references and to excellent literature summaries of bubbles, which cover empirical as well as theoretical literature on the rapidly evolving subject Scheinkman and Xiong (2004), Xiong (2013), Scherbina (2013) and Brunnermeier and Oehmke (2012).

Now consider a theoretical model, which incorporates these stylized facts. Building from the work of Miller (1977) and Harrison and Kreps (1978), Scheinkman and Xiong (2003, 2004) build a multi-period model where risk neutral agents have belief dispersion driven by overconfidence from different interpretation of a public signal. A bubble is created in the model where agents willingly buy the asset for prices above its fundamental value, because they believe they can resell the asset to a more optimistic buyer in the future. They are able to show that the size of the bubble increases with the amount of overconfidence in the agent's analysis of the signal. Also, along with the increase of bubble size they show in equilibrium that the bubble is accompanied by large increases in trading volume and increase volatility matching the stylized facts.

Xiong (2013) uses this earlier work to create a simple model in discrete time that relies on the risks neutral agents, and overconfidence in signal analysis. The model has a detailed and intuitive exposition and I urge readers to review the summary to gain a full understanding and intuition of the resell value concept.

Hong, Scheinkman and Xiong (2006) devise a model to analyze the relationship between asset float and speculative bubbles. Building an asset price bubble assuming a normal distribution, they are able to show that the float of the market is crucial in the formation of the price bubble. The float must be sufficiently small so that the optimists exert all the pricing power. Clearly, if there is restricted short selling and the marginal buyer is an optimist, then the pessimists have reduced power in arbitraging away a price bubble.

Next the research incorporated lending and credit constraints in the models. Geanakoplos (2010) created a model with a continuum of risk neutral agents and divergent expectations of the asset's future payoff probabilities. He was able to show the belief structure of pessimists mattered as well as the collateral constraints. This evolved into a model which not only had bubble characteristics but also modeled credit cycling, the bubble bursting, and the optimistic agents becoming bankrupt in the down states. Simsek (2013) extends this type of model to include different forms of optimism and pessimism. Further, showing that these different types of optimism have effects on the equilibrium. He and Xiong (2012) further extend this to show different equilibria that occur when the optimist must re borrow and settle in a period before the assets payoff.

What happens in defaulting states is not a simple question to answer. It depends on a wide array of factors depending on the borrower, the lender and the legal code of that region. It can become even more complicated if there are shareholders, equity holders, creditors and managers of a firm all attempting to act in their best interest. For this paper, I avoid modeling the default process, simply assuming a payoff structure in defaulting states. Much more realistic and complete methods for modeling bankruptcy exist. For readers interested in such a discussion I refer them to Crean (2009).

It is worth noting that Crean (2009) models bankruptcy in a more complete method using a binomial tree structure. An interesting result is the Jarrow and Turnbull (1995) credit model assumes a recovery rate and is not able to generate estimates of default loss. This means in the case of modeling SIRS firms with Crean (2009) defaulting outcomes, one cannot accurately price the risk using the Jarrow and Turnbull (1995) method. This causes concern for correctly pricing the risk of SIRS industries.

The overinvestment caused by bubbles deserves attention. If a bubble occurs in the share price of a company, the firm has access to inexpensive capital. This happens when companies issue new shares at an inflated price. Since managers receive compensation for the current market valuation of the firms it is in their best interest to issue more stock and invest the money into production and capacity. Gilchrist, Himmelberg and Huberman (2005) discuss in detail firms taking advantage of the bubble event to increase investment. They create a theoretical model, as well as, test their model empirically. Both their theoretical and empirical model show greater dispersion in investors' beliefs cause higher price deviations from fundamental values and greater investment in the firms. While existence of a bubble is not a sufficient condition for overinvestment, their model provides many examples where overinvestment occurs.

Analyzing overinvestment when agents disagree on the belief structure is not a trivial topic. To say whether or not an investment level is Pareto efficient or not, one must normally choose which agents belief structure is correct and which agent is being irrational in beliefs. Brunnermeier, Simsek and Xoing (2014) provide a framework and a belief neutral Pareto optimality condition where one can state, in certain cases, whether or not the allocation is efficient, without choosing which belief structure is correct. This criterion is simple: if the allocation is not optimal under any convex combination of agents beliefs then it must be belief neutral Pareto inefficient. If it is optimal under some convex combination, then one cannot say more than the allocation is belief neutral Pareto efficient, without judging which belief is correct. This is because at least one agent, or a combination of agents believes that the decision is optimal.

This criterion is used to create a model to show that a bubble in equity shares of a company will lead to real overinvestment in the firm. They are able to show in their model once prices leave their fundamental value, the overinvestment in the firms is belief neutral Pareto inefficient. Based on all combinations of investor's beliefs, every agent believes this investment level is too high, yet all assume another agent will pay the cost of this overvaluation. This models the commonly discussed "Greater Fool" theory in investment.

Fostel and Geanakoplos (2008) produce a model that shows leverage cycles can cause contagion issues and flight to collateral (quality). They show its possible to have contagion equilibria when downturns in one industry cause liquidity and leverage to cycle in other industries. This results in downturns in those industries as well. This can be incorporated into the SIRS model by contemplating a downturn in an industry caused by a collapse in another SIRS industry. This allows us to consider scenarios where banks or creditors can have large loss states where, default in one SIRS industry causes defaults in other upstream or downstream SIRS industries exacerbating aggregate losses.

If we assume that the SIRS demand shocks are the source of the risk one may introduce Caballero and Simsek (2013) and Li, Milne and Qui (2013) into the discussion. They developed a model where banks do not know the health of other banks which they lend to in an interbank market. This allows unhealthy banks to cause a contagion domino effect that can cripple the healthy banks. When this takes place, banks call in all loans possible and sell remaining assets at fire sale prices in order to raise liquidity. Further, the calling of assets to pay for the loans from these industries can cause a leverage cycle. Which could cause downturns in other SIRS industries, starting a downward spiral.

For further information on the bubble formation causes and effects on the real economy I direct readers to several well-written literature surveys and reviews: Scheinkman (2013), Scheinkman and Xiong (2004), Xiong (2013), Scherbina (2013) and Brunnermeier and Oehmke (2012).

My contribution to this growing field of research is in modifying some of the existing models by incorporating the SIRS model described in Crean and Milne (2015). I take the resale theory from Miller (1977) and Harrison and Kreps (1978) combined with the simple model of overinvestment from Brunnermeier, Simsek and Xoing (2014) to show that under differential belief structures agents will overvalue the equity shares of SIRS firms because of their resale values. This causes SIRS firms to overinvest and causes the underpricing of risk as judged by Jarrow and Turnbull (1995) and Merton (1974) credit models.

In some cases this is belief neutral Pareto inefficient overinvestment. In other cases assumptions are made about the accuracy of the agents belief structure in order to achieve the overinvestment result. Lastly, I discuss the difficulties of SIRS losses for bankers and policy makers.

Examples of Systemically important real sectors

In this section I give examples of SIRSs and the consequences that occur when their demand suddenly falls. I use current examples in this section to highlight the ongoing nature of the crises, occurring in these industries. While I only give a small number of examples in this section, I refer to Crean and Milne (2015) for a more complete list of SIRS, examples and how they fulfill these characteristics.

Mining

Mining is a very clear example of an SIRS firm. Asset levels are well above revenue levels, and have almost tripled revenue levels in the past few years in Canada[5]. One can also see the initial cost of purchasing land, plant, and equipment exceeded 100 billion dollars for the top 40 companies during 2013 and 2014[6]. Marginal costs are also low, as low as $20 per ton for iron ore, and $9.27 an ounce

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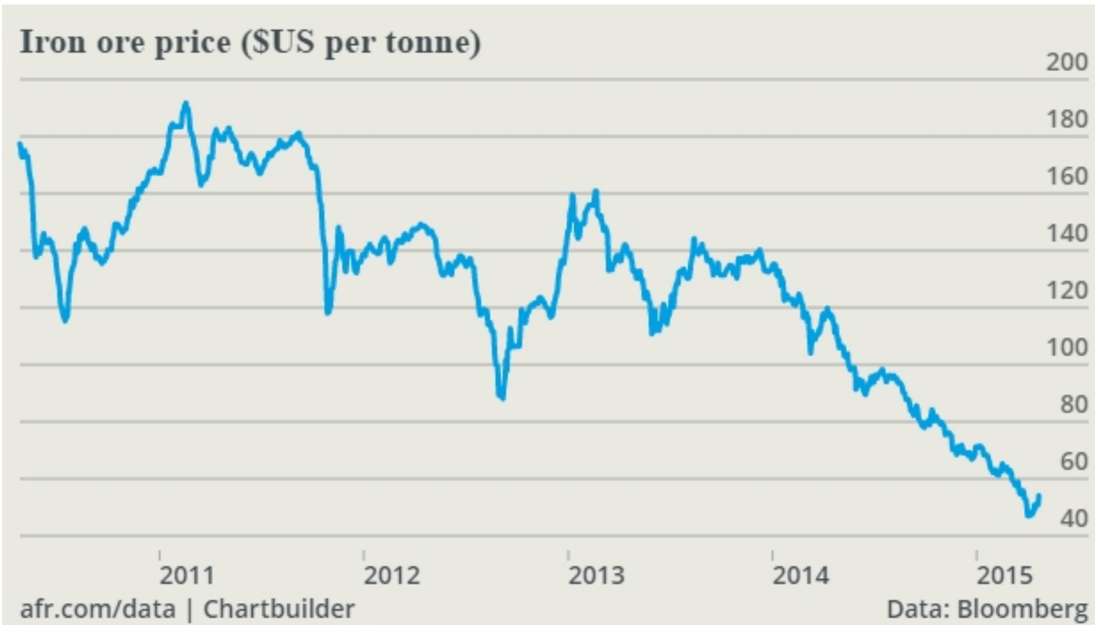
[5] See "Mine 2015: the gloves come off" by PWC; on page 40 they have balance sheet data of the aggregate top 40 mining companies. Retrieved from http://www.pwc.com.au/industry/energy-utilities-mining/publications/mine-trends.htm

[6] See "Mine 2015: the gloves come off" by PWC page 16 for the financial analysis of the top 40 firms. Retrieved from http://www.pwc.com.au/industry/energy-utilities-mining/publications/mine-trends.htm

for silver [7]. Revenue in this industry has swung widely due to large shifts in commodity prices. Iron ore prices fell over 50 percent, and coal prices fell 26 percent in the early months of 2015[8]. To give an example of the nature of volatility in prices and returns consider the graph of iron ore prices below[9].

Figure 1:



It is not uncommon for these firms to have large amounts of corporate debt, with over a fifth of firms stating they issued corporate debt to raise funds[10]. To further show the high levels of return volatility and possible losses for these firms, the top 40 firms return on equity changed from 3 to 7 percent between 2013 and

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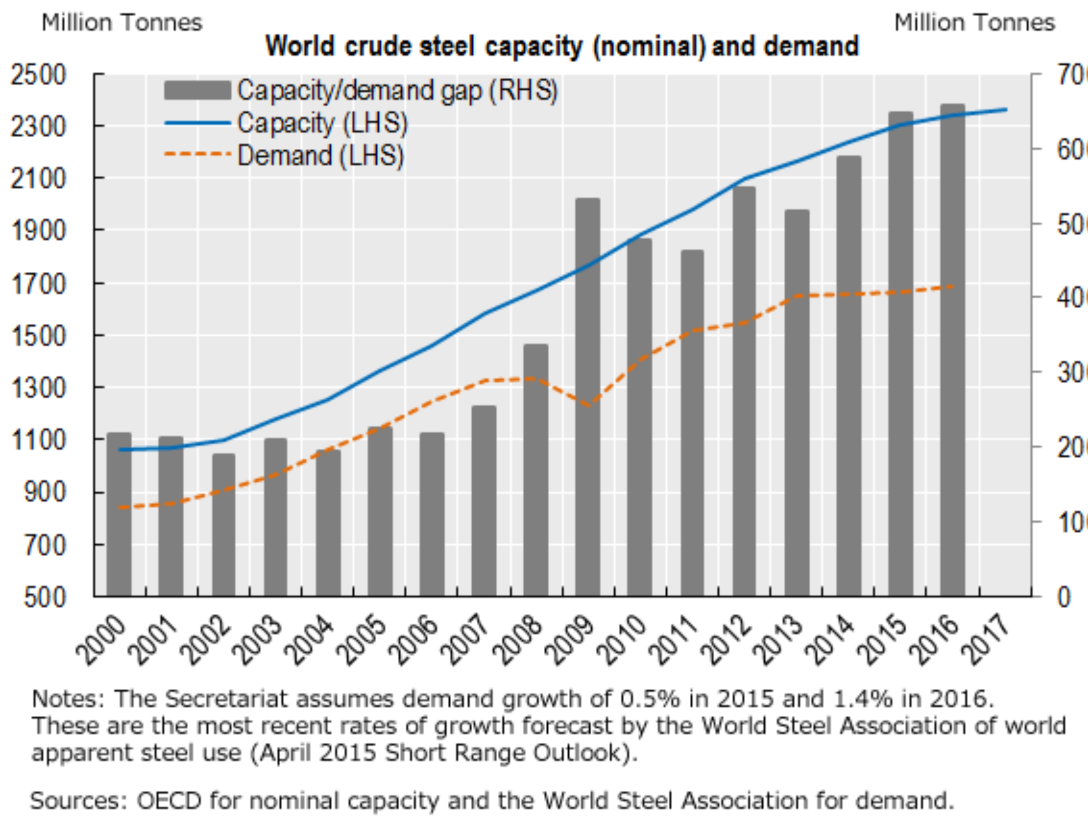
[7] "World Silver survey 2014": by the World Silver Institute. Page 34 for cost studies. Retrieved from *kghm.com/sites/kghm2014/files/**world_silver_survey**_2014.pd*
[8] See "Mine 2015: the gloves come off" by PWC; page 5. Retrieved from http://www.pwc.com.au/industry/energy-utilities-mining/publications/mine-trends.htm
[9] http://afrsmartinvestor.com.au/r/2009-2014/AFR/2014/12/17/Photos/093e53ec-8625-11e4-bb4e-c3c229afcfb2_Iron-ore-price-US-per-tonne-Mid-Price_chartbuilder.png
[10] See "Gold, Silver and copper price report 2015" by PWC page 17 Retrieved from http://www.pwc.com/ca/en/mining/global-gold-price-survey-results.jhtml

2014[11]. Overcapacity can be chronic in the mining and related manufacturing industries. See figure 1.1 below for an example from the steel industry[12].

Figure 1.1:



It is also easy to imagine the strong competition in this market as the top 40 firms and the rest of the industry compete for market share. This can be seen further from the low returns on equity received by the shareholders. Problems in

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[11] See Mine 2015: the gloves come off by PWC: Page 23 Retrieved from http://www.pwc.com.au/industry/energy-utilities-mining/publications/mine-trends.htm

[12] Figure 1.1 Retrieved from http://www.oecd.org/media/oecdorg/directorates/directorateforsciencetechnologyandindustry/steel/world-crude-steel-capacity-and-demand-373x259.JPG

these sectors are likely to worsen in the coming months with Copper futures for August declining 1.7 percent, setting a bad omen for the commodity industry[13].

It is worth looking more carefully at the iron ore industry and the collapse of iron ore prices. Over an 18-month period iron ore prices have fallen from $130 a ton to a low of $44.1 a ton, a 77% fall in iron ore price since its peak[14]. Further some are forecasting a fall below $40 a ton[15]. Some companies have extremely low marginal costs and have average costs of below $20 a ton (e.g. Rio Tinto). This company has also stated that its break-even point will be $39 a ton. Given previous events it is conceivable that prices may fall further and endanger this firm[16]. BHP Billiton Ltd has lowered its average cost to $20 a ton[17]. One can see from the iron ore price graph above and the dramatic nature of the price fall from a peak of $191.10 to below $50.00 a ton that a seemingly safe and high profits sector can be hit by extremely large demand shocks and excess capacity, and thereby become unstable.

With large price falls, low returns on equity, and revenues so tied to the sale price it is not hard to think of scenarios, where the down turn in iron prices can effect the mining industries ability to pay back its loans. Further from the nature of

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13 Deaux, J (2015, July 22) This Measure of Copper Is Another Bad Omen for the Commodities Meltdown. Bloomberg Retrieved from http://www.bloomberg.com/

14 Sheppard, D. Terazono, Eand Hume, N (2015, July 20) Commodity Prices head for 13-year low. Financial Times Retrieved from http://www.ft.com

15 Ng, J and Paton, J (2015, July 29) Iron In Bull Market as Forrest Dismisses Armageddon Prices. Bloomberg Retrieved from http://www.bloomberg.com/

16 (2015, April 17) Rio Tinto: we'll thrive on lower ore prices while others suffer, says boss. The Guardian Retrieved from http://www.theguardian.com/

17 Riseboroughjuan, J and Spinetto, P (2015, January 12) Vale seen as Overtaking CHP, Rio as Cheapest Iron Shipper. Bloomberg Retrieved from http://www.bloomberg.com/

SIRS firms they may be required to sell off excess stocks, even at a price below marginal cost. This is because of the need to raise liquid assets to service their loans. This crisis in the iron ore sector seems unlikely to disappear in the near future. Fresh supplies are expected to come from Rio, BHP Biliton and Vale, three of the largest iron ore companies implying low prices[18], causing further disruption in the industry.

This has been problematic for Australia who has iron ore as its biggest export earner. One can see the iron ore price fall along with other commodity pricing declines, has lowered the Australian dollar[19] over 10 percent against the US dollar so far this year[20]. To further this problem the down turn could lead to a larger unemployment rate in Australia[21]. One should note the similarities between Australia's relationship with commodities and Canada's, foreshadowing potential problems in Canada's resource industry.

Oil Sands

The Canadian Oil sands are another prime example. The primary recovery costs of mining are $30.32/bbl and $47.57/bbl for steam assisted gravity drainage[22]. Fixed capital and initial investment in the projects make up half of the total costs for

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[18] Hume, N (2015, July 2) Iron ore in biggest daily fall since March. Financial Times Retrieved from http://www.ft.com/

[19] Australian Associated Press (2015, July 7) Australian dollar down amid iron ore, oil price falls. The Australian Retrieved from http://www.theaustralian.com.au/

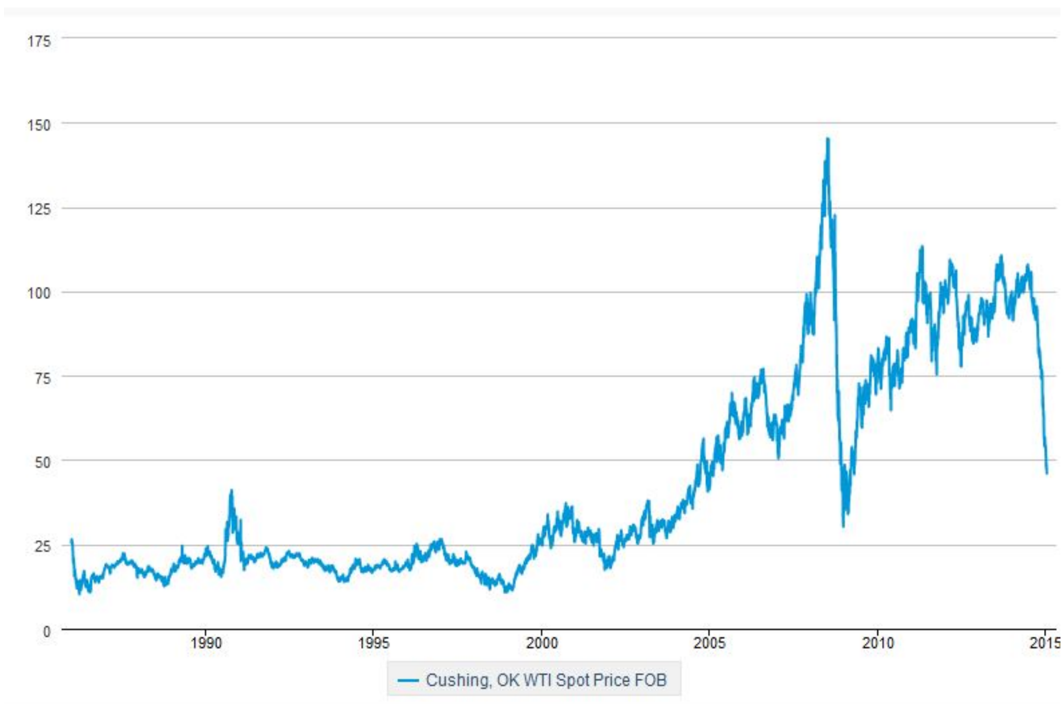
[20] Adinolfi, J (2015, July 22) Falling Iron Ore Prices Weigh on Australia's Currency. Market Watch Retrieved from http://www.marketwatch.com/

[21] Sarkar, D (2015, July 29) Job losses and closures loom over mining sector in Australia International Business Retrieved from http://www.ibtimes.com.au/

[22] See figure E1 Canadian Oil Sands Supply Cost and Development Projects (2012-2046) Retrieved from http://www.ceri.ca/index.php?option=com_content&view=article&id=106:ceri-study-133-oil-sands-update-2012-2046

each extraction method[23]. It is projected that the total development of all oil sands projects will require initial capital investment of $270.4 billion between 2012 and 2046. This indicates the likelihood that companies will borrow from banks to finance these projects. Another example of this large initial investment is Petro Canada developing a $33 billion Fort Hills project[24]. In addition to these low marginal costs and massive initial investment levels one can see the volatile and uncertain future revenues by looking at figure 2[25], and considering the fact that prices have fallen 20% this month alone[26].

Figure 2:



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[23] See executive summary page xiv of Canadian Oil Sands Supply Cost and Development Projects (2012-2046) Retrieved from http://www.ceri.ca/index.php?option=com_content&view=article&id=106:ceri-study-133-oil-sands-update-2012-2046
[24] See Canadian Oil sands Overview report from Sunshine Oil Sands Retrieved from http://www.sunshineoilsands.com/operations/oilsands_overview.html
[25] http://blogs-images.forbes.com/danielfisher/files/2015/01/eia-oil-price.jpg
[26] Friedman, N (2015, July 27) Oil Prices Fall to Four-Month Low Amid Chinese Share Rout. The Wall Street Journal Retrieved from http://www.wsj.com/

It is clear many oil sand companies will not be able to operate with low oil prices and more companies will be in danger if prices continue to fall[27]. Based on supply costs estimates, a large number of oil sand projects will no longer be feasible if the price falls below $78 in West Texas Intermediate prices (WTI)[28].

It is clear that a further drop in oil prices will cause more havoc for oil sands production. With some new oil sands projects starting to become infeasible at $58.61 WTI, that price drop could compromise the industry. There has been recent canceling of 60 billion dollars worth of oil sands projects[29]. Much of the $33 billion dollar Petro Canada project (which has also been put on hold[30]) will be funded by loans: it could be devastating for the creditors to issue such a loan before a surprising fall in price. The situation becomes riskier if projects with excess stocks are forced to sell below their marginal costs, in order to service debt in the short run, driving prices lower and endangering more firms.

Housing

The housing sector is a third SIRS example in this section. While it may not appear to fit the SIRS model, a closer examination of the sector reveals a SIRS identity. Upfront investments in the housing market are extremely large with a 20

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[27] See "A different kind of oil sands by" Cenovus energy page 6 for graphs of competitors costs of extraction. Retrieved from *www.cenovus.com/invest/docs/2013/corporate-update.pdf*

[28]See Canadian Oil Sands costs and development projects page 32. Retrieved from http://www.ceri.ca/index.php?option=com_content&view=article&id=106:ceri-study-133-oil-sands-update-2012-2046

[29] Adams, C (2015, July 26) Global oil puts $200 billion in projects on ice. $60 billion in oilsands alone. Financial times Retrieved from http://www.ft.com/

[30] Lewis, J (2015, January 6) Oil's Plunge threatens Suncor's Fort Hills development. Globe and Mail Retrieved from http://www.theglobeandmail.com/

percent down payment required in Canada[31]. The remaining funds are borrowed from banks in the form of mortgages. Marginal costs are low, being the upkeep of the house. Revenue from the house can be viewed as the possible net resale value. The resale value can be extremely volatile. This is demonstrated by reports from Scotia Bank in 2012 predicting a 10% drop in housing prices[32], whereas prices increased 8% over the next 3 years[33].

An added danger in these markets is that a down turn in prices can quickly lead to homes being worth less than is owed on the mortgage. Negative equity and forced sales can cause a chain reaction of foreclosures, leading to homes being sold by banks, lowering house prices, which in turn causes more foreclosures[34]. One can see the effects of the housing bubble and the disaster it caused in the United States.

In Canada there is no immunity to a possible housing bubble. Some estimates show an existence of a housing bubble with prices being 7-20 percent above fundamental values[35], while other estimates range between 10 and 30 percent[36]. When this is combined with a forecasted mortgage rate increase of about

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[31] Page 4 of Special Report Canadian Housing August 8th 2012 by Scotia bank. Retrieved from *www.gbm.scotiabank.com/English/bns_econ/spaug8.pdf*
[32] Page 2 of Special Report Canadian Housing August 8th 2012 by Scotia bank. Retrieved from *www.gbm.scotiabank.com/English/bns_econ/spaug8.pdf*
[33] See page one for statement of 8% housing pricing rise. See page 8 for graph of housing prices in Canada as well as a table of percent changes in Canada. From Global Real Estate Trends by Scotia bank. Note that the same company issued both of these reports gives extra evidence of the nature of forecasting housing prices. Retrieved from *www.gbm.**scotiabank**.com/English/bns_econ/re**trends**.pdf*
[34] This is described in detail and is the topic of much discussion in House of Debt by Mian and Sufi (2015).
[35] See page 6 of IMF Country Report No. 15/22 on Canada. Retrieved from www.imf.org/external/pubs/ft/scr/2015/cr1522.pdf
[36] Financial System Review, December 2014 by the Bank of Canada page 16. Retrieved from http://www.bankofcanada.ca/publications/fsr/

1-2%[37] it could lead to a potential 10% deterioration in housing affordability by the end of 2016[38]. This would cause a significant drop in demand causing an SIRS crisis to emerge.

The consequences of a potential collapse in housing demand and the resulting SIRS collapse on the Canadian economy is demonstrated by the result of a stress test done on these scenarios. A recent report published stated that private mortgage insurers could face losses of $17 billion. In addition, the federal government would be left with a $9 billion dollar cost of recapitalizing mortgage insurers[39]. This stress test report also acts as additional verification of the housing market containing the SIRS characteristics.

Canada is not alone in having housing sector problems: other countries are also experiencing housing bubbles. Recall the devastating effects of the U.S. subprime mortgage crisis occurring in 2008. Another example, is the Chinese real estate sector[40], which has created problems for the Chinese economy and lowered the demand for commodities. This shows how a downturn in a Chinese housing SRIS

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[37] See page 4 of Housing market outlook second quarter 2015 by Canadian mortgage and Housing Cooperation. Retrieved from https://www03.cmhc-schl.gc.ca/catalog/productDetail.cfm?cat=63&itm=1&lang=en&sid=SOgRDJORvf0gnrtDxixwIW3K8vkspNrjUfzGJF5oCdkbJGpGt9kZnQL61bVG6CvP&fr=1438746189998

[38] See page 6 of Global views October 10th 2014 by Scotiabank. Retrieved from *www.gbm.**scotiabank**.com/English/bns_econ/globalviews141010.pdf*

[39] Mortgage Insurance as a Macroprudential tool by Thorsten V. Koeppl and James MacGee (2015).

[40] Plender, J (2015, July 21) Investors cannot see through market froth. Financial Times Retrieved from http://www.ft.com/

can lead to downturn in commodity markets endangering Australian and Canadian SIRS industries[41].

New Zealand Milk and Dairy

The dairy industry is a last, and perhaps peculiar example of a SIRS type. It is hoped this example will give readers an indication of sectors, which can be classified as SIRS. Milk prices have fallen more then 50% since February of this year. This follows an over expansion of dairy farms during the boom in milk prices, causing many farms and companies to have overcapacity. This was illustrated by the dumping of milk that producers could not sell. I hope this inclusion illustrates the wide variety of possible SIRS that can exist[42]. Noting that this is a potential SIRS since the amount dairy farms borrow from banks is currently unknown. Banks however should aggregate loans made to dairy farms, to indicate whether this is a SIRS industry.

The last four examples show there are many potential SIRS crises, which can effect banks and cripple economies in the future. More worrying is the contagion effect that can be seen in a crisis when downturns in one sector cause downturns in other sectors. The beginning of this paper provides some historical examples of how a few key SIRS industries caused much of the damage to the economy. This increases the need to be able to price risk appropriately.

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[41] Blitz, R (2015, July 21) Canada's dollar hit by China and oil woes. Financial Times Retrieved from http://www.ft.com/

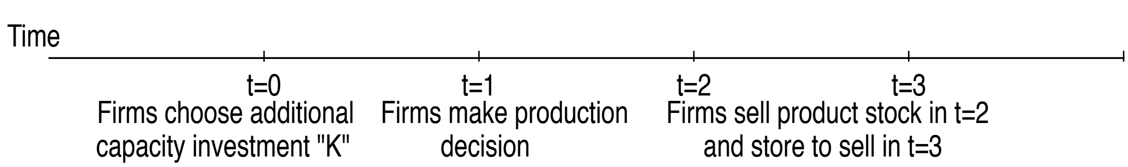
[42] All information in this paragraph has come from Onselen, L (2015, July 23) NZ's commodities crash Rivals Australia's. Macro Business Retrieved from http://www.macrobusiness.com.au

With this in mind the next section builds a model describing the SIRS firm structure taken from Crean and Milne (2015). It also incorporates elements from Brunnermeier, Simsek and Xoing (2014) to show the overinvestment in these industries. Lastly, I will show that Jarrow and Turnbull (1995) and Merton (1974) models for credit risk underprice the risk in the economy. Thus, without changing credit risk techniques, more credit risk will be adopted than would be otherwise and this puts banks at greater risk for these SIRS events (see also Crean and Milne (2105)).

A Model of SIRS firms

I start the modeling process by giving a description and justification for the firm structure described in Crean and Milne (2015). A SIRS firm has low marginal cost and capacity constraints, which can also be thought of as a reverse "L" shaped marginal cost curve. They exist in competitive industries, and firms must invest in physical capital, such as manufacturing plants. Once these plants are established, the marginal cost of producing another good is low. However, producing an amount that requires additional plants to be built will incur further expenses.

Figure 4.1

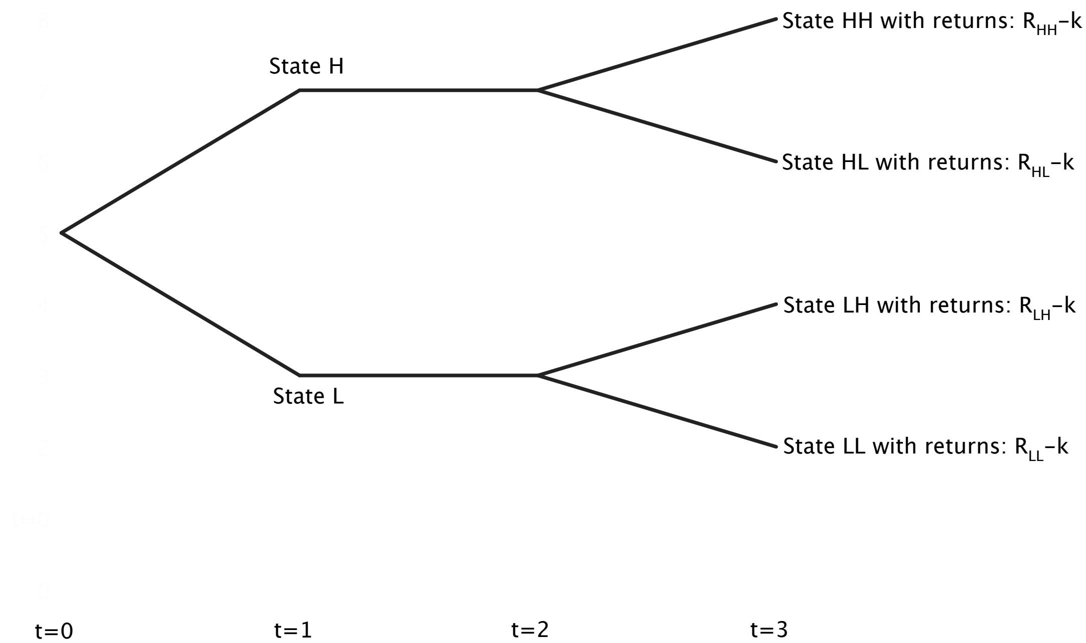


At time t=0 the SIRS firm chooses what level of additional capacity "K" in which to invest in (the firm may already have existing capacity). Graphically this would be choosing the horizontal location of the constraint. In reality the firm would be choosing how many plants to build. Firms will choose the capacity level that maximizes the return on their investment.

After the investment is completed and the new capacity is in place, the firm produces in period t=1. This production takes place before the state of demand is observed. Thus, the firm chooses its production level such that profit is maximized based on the expected demand curve. Once the production is completed, the state of demand is realized. The firms then choose what stock of products to sell in period t=2 and what quantity to store in order to sell in period t=3. This decision is made to maximize total discounted profits based on expectations of future demand. The revenue is realized in periods t=2 and t=3 as firms sell their products while observing whether the demand curve has shifted from the initial demand curve at time t=1.

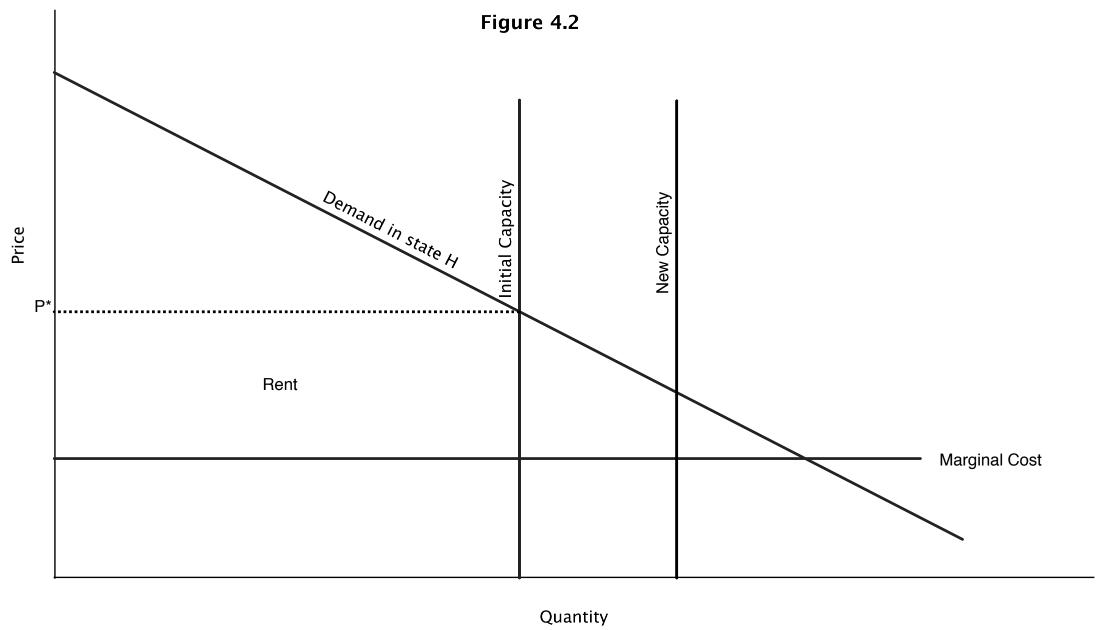
In this process investors (which I assume are risk neutral) in the firms speculate on the future demand curves. The decisions of the firm's production and investment levels are dependent on the views of the investors. Greater optimism in future demand will lead to more investment in capacity and higher quantities of production. Further, I assume there are a sufficient number of optimists in each state, so that the optimistic investors may purchase all shares of the firm, thus increasing investment and production levels. The states of demand that investors are speculating on can be depicted in figure 3, where "R" will denote the total revenue earned in each of the final states occurrence.

Figure 3



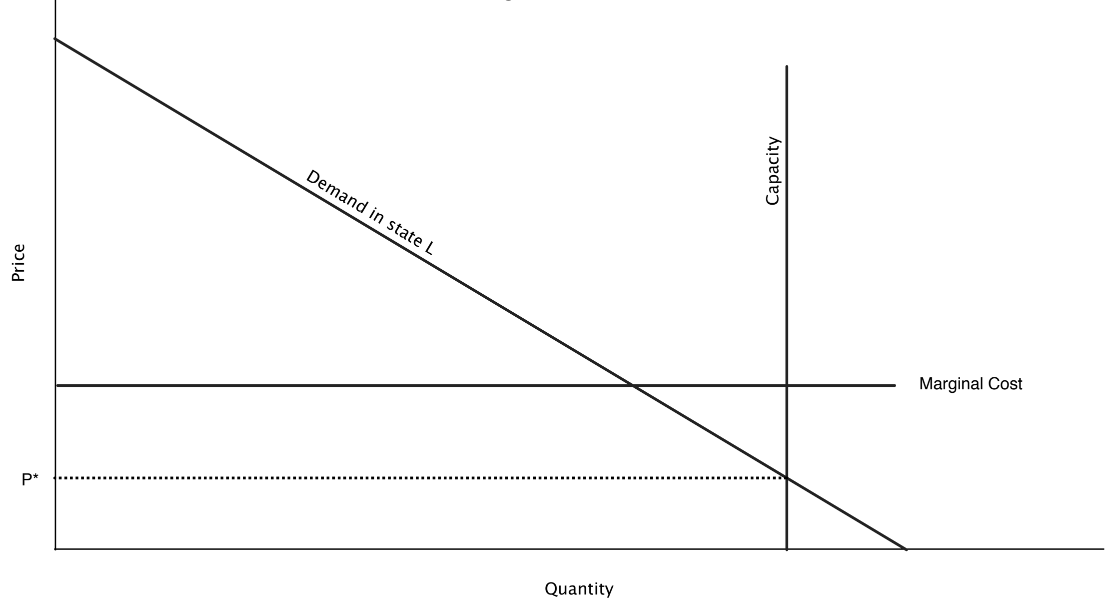
If there is a high demand the firm will earn a rent and positive returns on the capacity investment, since capacity constraint acts as a barrier to entry. Overtime more firms will enter, or existing firms will increase their capacity to reduce this rent. Due to the strong competition in the market, earning perpetually high rents and profits is impossible. This is illustrated in figure 4.2.

Figure 4.2



However, low demand is problematic for firms. Since they have already invested in the capacity they cannot simply exit the industry. If storage costs are low, firms will attempt to store goods until more opportunistic times. However if storage costs are high, firms may be forced to sell product at prices below their marginal costs, earning a negative return on the capacity investment. This is depicted graphically illustrated in figure 4.3.

Figure 4.3



This dynamic demonstrates when the firm's shareholders choose the optimal amount of capital to invest in capacity; they must also consider the probability distribution over these different demand curves. Their solution will be to maximize the present expected value of their returns.

Lastly, note that the SIRS model presented here is the base case in Crean and Milne (2015). This is due to its ease in use. There are many more complicated, realistic versions presented in Crean and Milne (2015). However, the base case is particularly enlightening for exploring the basic results presented in this section.

The model introduced and analyzed in this section is largely adapted from the overinvestment model introduced in Brunnermeier, Simsek and Xoing (2014), and modified to fit the SIRS framework illustrated in Crean and Milne (2015). This is achieved by adjusting the firm in the Brunnermeier, Simsek and Xoing (2014) model to incorporate features from SIRS firms (low marginal costs, capacity constraints and uncertainty of future demand).

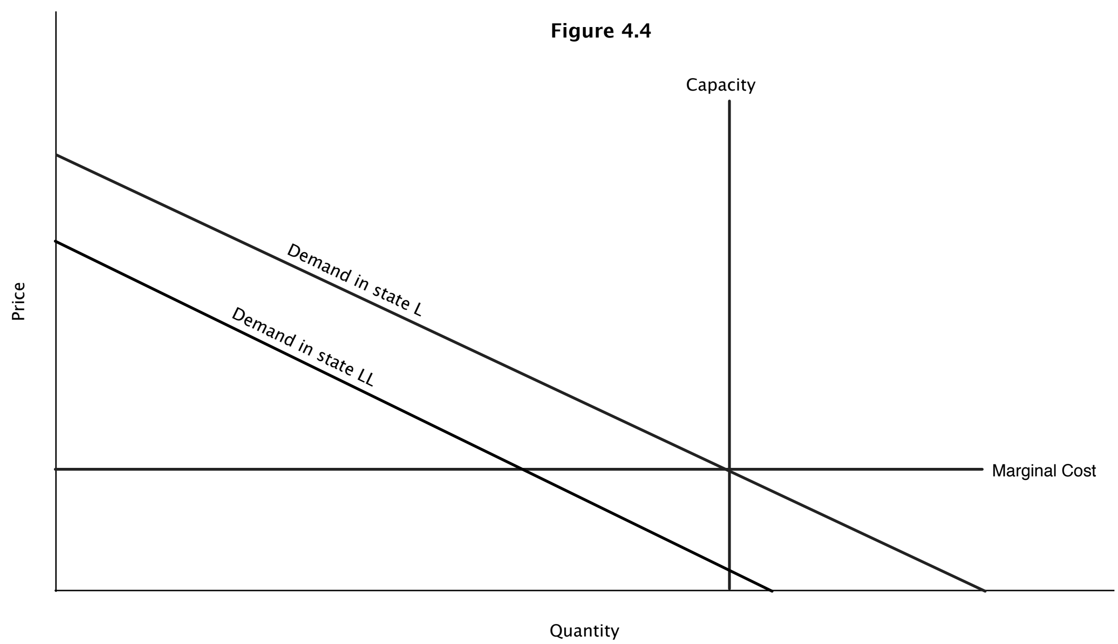
To begin, consider the tree structure of the firm in figure 3. Where $R_{HH} > R_{HL} > R_{LH} > R_{LL}$ are the returns in each state and "K" is the capital invested in capacity at time t=0. One can model a SIRS firm in this way since the firm is choosing which capacity constraint it has, in period t=0. Once the capacity investment is completed but before observing the state of demand, firms will choose how much to produce in period t=1. After observing the state of demand in period t=1 the firm chooses how much they will sell in periods t=2 and t=3. The firm sells and stores the goods in such a way that maximizes combined discounted profits in periods two and three based on expectations of future demand, taking storage costs and previous production decisions as given.

Rather than having a tree structure where profits are shown in each state and discounted to make a total profit, the approach of implicitly summing all the profits is taken representing the result as a return on the capital investment given the final occurrence of each state. Further, one can justify the simple return structure; by the more capital invested in capacity the lower return the capital would have. Underinvesting in capital will lead to a very large return on capital. If a firm is overinvesting in capital there will be very small or negative returns on capital.

Now one must interpret the magnitude of each of the returns. In the higher states there is a high demand curve, since the demand curves have shifted upwards after their observation in period t=1. This causes returns to be higher in each of these states (because of the rent discussed previously). Higher demand curves will mean goods are sold at higher prices ceteris paribus. This is represented in the tree as, $R_{HH} - K > R_{HL} - K > R_{LH} - K > 0$, where "K" is the capital level invested in capacity.

The more interesting case is what happens in state L. One can incorporate the SIRS firm further by thinking of the demand curve intercepting the capacity constraint at the marginal cost. This causes price to be equal to marginal cost from the strong competition of other SIRS firms. If the demand curves shifts up slightly in a higher state then the firm can earn a positive return. However, if there is a downward shift in demand then the firms demand curve will intercept the capacity constraint below marginal cost. Further, since the firm has chosen the production amount two periods ago it cannot alter production. This means goods will be sold at "fire sale price" (assuming high storage costs). Ultimately, this will cause the firm to lose money and earn negative returns on the investment in the event of state LL i.e., $R_{LL} - K < 0$. This can be illustrated graphically in figure 4.4.

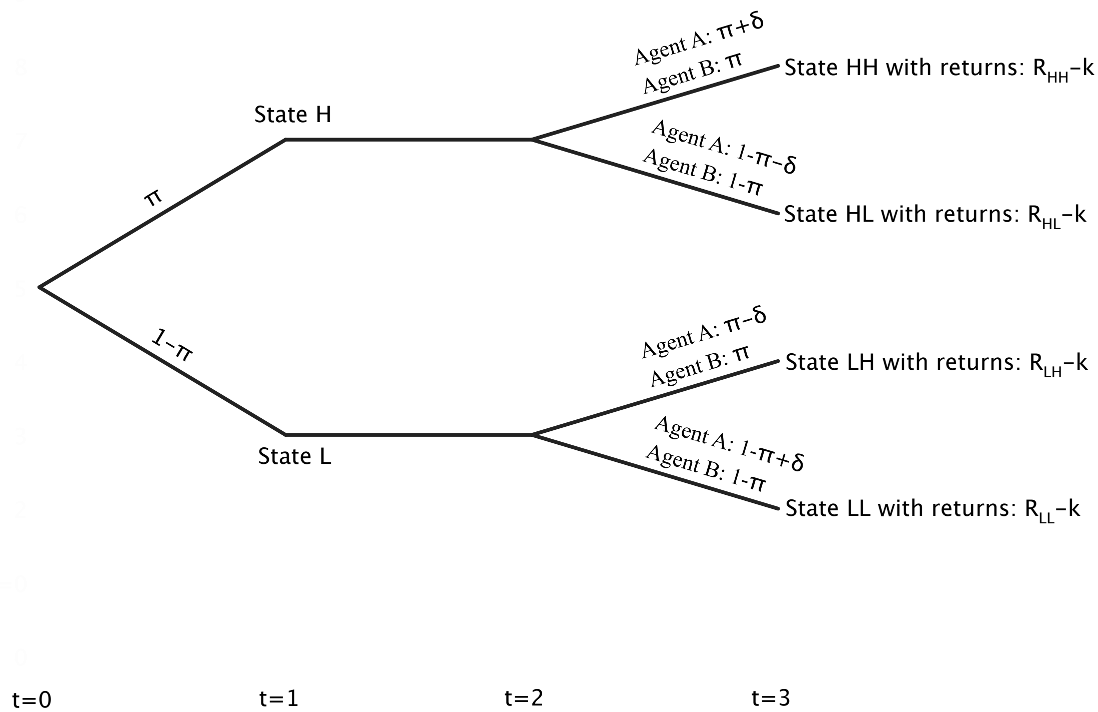
Figure 4.4



But now, let there be two types of shareholders in the model, type A and type B. Both agents are risk neutral and both groups are sufficiently large enough to buy any outstanding float in the market. They differ only in their subjective-probabilities of different states of demand. Just as the belief structure in Brunnermeier, Simsek and Xoing (2014), type A believes the market follows much more of a trend than type B i.e., A is more optimistic in high demand states and more pessimistic in low demand states.

As in Brunnermeier, Simsek and Xoing (2014), I assume when t=0 both A and B have the same probability π of the demand shifting up to state H. In the next period the belief dispersion occurs. I define δ to be the magnitude of belief dispersion occurring. i.e., in the up state A believes that there is a $\pi + \delta$ percent chance of another demand shift up to state HH and a $\pi - \delta$ percent chance of state LH occurring. Clearly, an increase in δ increases the total amount of belief dispersion present in the model. The payoffs with their belief dispersion are given in figure 5.

Figure 5



With this structure in place we have a situation where the most optimistic agent will buy all outstanding shares in each state. Also, I make the assumption that there is no bargaining such that each agent who buys assets will buy at their reservation price (there is perfect competition in buying the assets).

Now defining $V_{t,\omega}^{j}$ to be the value of the share in the perspective of agent of type j, at time t and in state ω when there is no resale option. Also denote $p_{t,\omega}$ be the price of the shares in state ω at time t given that resale is possible. Hence, one can derive.

$$V_{1,H}^{A} = (\pi + \delta)(R_{HH} - K) + (1 - \pi - \delta)(R_{HL} - K)$$

$$V_{1,L}^{A} = (\pi - \delta)(R_{LH} - K) + (1 - \pi + \delta)(R_{LL} - K)$$

$$V_{1,H}^{B} = (\pi)(R_{HH} - K) + (1 - \pi)(R_{HL} - K)$$

$$V_{1,L}^{B} = (\pi)(R_{LH} - K) + (1 - \pi)(R_{LL} - K)$$

$V_0^A = \pi[(\pi + \delta)(R_{HH} - K) + (1 - \pi - \delta)(R_{HL} - K)] +$
$(1 - \pi)[(\pi - \delta)(R_{LH} - K) + (1 - \pi + \delta)(R_{LL} - K)]$

$V_0^B = \pi[(\pi)(R_{HH} - K) + (1 - \pi)(R_{HL} - K)] +$
$(1 - \pi)[(\pi)(R_{LH} - K) + (1 - \pi)(R_{LL} - K)]$

$p_{1,H} = (\pi + \delta)(R_{HH} - K) + (1 - \pi - \delta)(R_{HL} - K)$

$p_{1,L} = (\pi)(R_{LH} - K) + (1 - \pi)(R_{LL} - K)$

$p_0 = \pi[(\pi + \delta)(R_{HH} - K) + (1 - \pi - \delta)(R_{HL} - K)] +$
$(1 - \pi)[(\pi)(R_{LH} - K) + (1 - \pi)(R_{LL} - K)]$

Note that $V_{1,H}^A$, $V_{1,L}^A$, $V_{1,H}^B$, and $V_{1,L}^B$ are simply the expected value given each state's occurrence. Since, if agents cannot resell the asset, they must hold it to maturity. This causes the value of the asset to be their expectation of future payoffs. This leaves the price at time t=1 equal to the most optimistic agents valuation in each state. Since investors facing strong competition will bid the price up to their valuation of the asset. Lastly, the price at time t=0 will be equal to the agent's expected resale value in time t=1. Since any other price would result in either excess supply or excess demand. In future variations on the model I will simply give the values leaving the reader to recall this description.

One can easily see that the prices are greater than the valuations in each state. This is because the most optimistic agent in each case will buy the asset and the less optimistic agent is willing to hold the asset at this price. They know they can resell the asset to a more optimistic buyer. If the price was less than the optimist's valuation then a pessimist could promptly buy all assets and immediately resell the assets to an optimist making an arbitrage profit.

With this dynamic in place, both agents will agree on the price at time t=0. Further, both agents will be willing to hold the asset because of its resale value. Yet, both agents have personal expectations that the share is worth less than the price. The exact amount of the overvaluation is given below.

$$p_0 - V_0^A = (1-\pi)\delta[(R_{LH} - K) - (R_{LL} - K)] > 0$$

$$p_0 - V_0^B = (\pi)\delta[(R_{HH} - K) - (R_{HL} - K)] > 0$$

This shows that both agent types are willing to buy the asset at a price greater than what they believe the fundamental value of the asset to be. This indicates the existence of an asset price bubble, which is driven entirely by the resale value of the asset. In this dynamic both agent types believe the other can be a "greater fool" and believe that they can make a positive profit by exploiting the other for their price miscalculation.

Since the SIRS firm described above one would expect $R_{LL} - K$ to be negative, hence it can be useful to examine the pricing of state LL derivative in periods t=0 and t=1.

$$V_{1,LL}^A = (1-\pi+\delta)(R_{LL} - K) \quad V_{0,LL}^A = (1-\pi)(1-\pi+\delta)(R_{LL} - K)$$

$$V_{1,LL}^B = (1-\pi)(R_{LL} - K) \qquad V_{1,LL}^B = (1-\pi)(1-\pi)(R_{LL} - K)$$

$$p_{0,LL} = (1-\pi)(1-\pi+\delta)(R_{LL} - K)$$

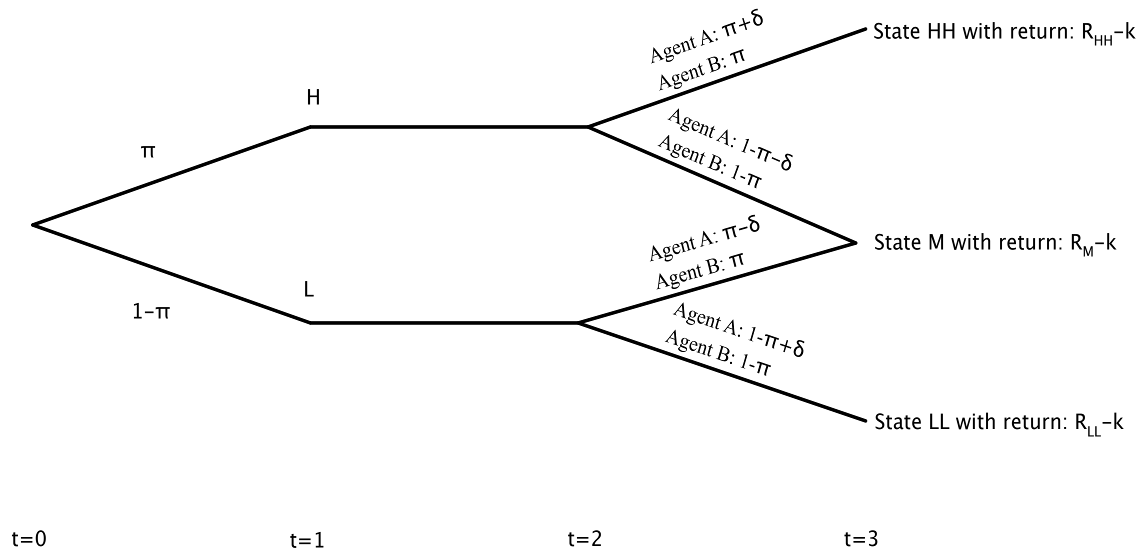
This demonstrates that agent A is willing to take on more downside risk than he would be if the resale option did not exist. This is because he can unload the debt possibility to agent B in the occurrence of state L. With this in mind agent A will take on more risk, since he will not intend to hold it until maturity. This shows that the risk is underpriced from the belief structure of agent A. Further if one makes the assumption that agent A has the correct belief structure then not only is agent A underpricing the risk but the entire model is as well.

Now an extremely important aside is that this shows that agent A is willing to pay more for a defaulting bond of this type with a resale option than the defaulting bond if agent A is forced to hold until the maturity, which would then be priced based on his probabilities. What makes this result so important is it shows that the Jarrow and Turnbull (1995) credit pricing model underprices the risk in this scenario. Underpricing this risk obviously causes agents to be less wary of the possible down state as they would otherwise and take on large amounts of risk.

One can take this result one step further and state that the Merton model also underprices the risk. Thus, one can now conclude that there is an asset bubble and an underpricing of credit risk occurring in this model of SIRS firms, the magnitude of both grow linearly with disagreement in the model "δ".

Showing this process causes overinvestment in the SIRS firm is more challenging. Since one must also be able to describe from whose perspective there is overinvestment and the exact amount of overinvestment. Overinvestment is shown in a slightly less general case first and then in more generalized models. I first make the tree recombe such that $R_{HH} - R_{HL} = R_{LH} - R_{LL}$ and $R_{HL} = R_{LH}$, which I state as R_M for simplicity, as seen in figure 6. This serves the purpose of equating firms A's and B's valuation of the firm at period t=0. This makes it easy to discern what the optimal investment level of the firm would be, absent any resale value and without having to incorporate issues of shareholder voting rights.

Figure 6



With these assumptions in mind, agents perceive the fundamental values and the price at t=0 as:

$$V_0^A = \pi(\pi+\delta)(R_{HH}-K) + \{\pi(1-\pi-\delta) + (1-\pi)(\pi-\delta)\}(R_m - K) + (1-\pi)(1-\pi+\delta)(R_{LL}-K)$$

$$V_0^B = \pi(\pi)(R_{HH}-K) + 2\{(1-\pi)(\pi)\}(R_m-K) + (1-\pi)(1-\pi)(R_{LL}-K)$$

$$p_0 = \pi(\pi+\delta)(R_{HH}-K) + \{\pi(1-\pi-\delta) + (1-\pi)(\pi)](R_m-K) + (1-\pi)(1-\pi)(R_{LL}-K)$$

Note that with some simple rearranging $V_0^A = V_0^B$ and $p_0 - V_0^B = \delta\,[(R_{HH}) - (R_M)] > 0$, hence the bubble still exists for this model. Thus all previous results still apply i.e., there is an asset price bubble and the underpricing of risk grows with the belief dispersion in the model.

Suppose there is no option to resale. Both A and B will want to maximize the value of their shares (optimize the initial capital investment in capacity so that their returns are maximized) based on their belief structures. Mathematically this will be expressed as;

$$\text{Maximize}[K * V_0^A] = \text{Maximize}[K * V_0^B] =$$
$$\text{Maximize}[K * \pi(\pi)(R_{HH} - K) + 2\{(1-\pi)(\pi)](R_m - K)$$
$$+ (1-\pi)(1-\pi)(R_{LL} - K)]$$

which has a first order condition of:

$$\frac{\pi^2 R_{HH} + 2\pi(1-\pi)R_M + (1-\pi)^2 R_{LL}}{2} = K^*$$

However, with agents agreeing on the price p_0, it is reasonable to assume they will maximize the present valuation of the shares. They believe they will be able to resell their shares at an inflated price to an optimist. This can be expressed mathematically as:

$$\max\,[K * p_0] =$$
$$\text{Max}[K *$$
$$\{\,\pi(\pi+\delta)(R_{HH} - K) + \pi\{(1-\pi-\delta) + (1-\pi)](R_m - K) + (1-\pi)^2(R_{LL} - K)\}]$$

Which has a first order condition of:

$$K^{**} = \frac{\pi(\pi+\delta)(R_{HH}) + \{\pi(1-\pi-\delta) + (1-\pi)(\pi)](R_m) + (1-\pi)(1-\pi)(R_{LL})}{2}$$

Further, since $R_{HH} > R_M$ the firm is overinvested by $\frac{\delta(R_{HH}-R_M)}{2}$

As stated in Brunnermeier, Simsek and Xoing (2014) under divergent expectations and assuming the social planner does not know the true probabilities of events occurring, the best the planner can do is optimize along a convex combination of beliefs. In this case the payoff structure was chosen as to equate their expectations while maintaining divergent beliefs. Hence, the investment level chosen is a belief neutral Pareto inefficient overinvestment of $\frac{\delta(R_{HH}-R_M)}{2}$.

The dispersion of agents' beliefs is the driving force for the asset price bubble and the overinvestment in the model. Further, both of these effects grow linearly with the amount of dispersion present in the model. Lastly, these effects also grow with the amount of dispersion in different states' return. Intuitively, in a case where all states give the same return there would be no overinvestment or price bubble. The other extreme would be an infinite difference between returns in which case the expectation would be the limit of overinvestment and the price bubble would approach infinity.

Returning to the more generalized tree structure, some of the results must be modified. We can no longer state the exact amount of overinvestment (since we do not know the optimal amount of investment). Without deciding which agent is correct in their view, one can only state whether or not the investment level is inside or outside the convex combination of agent's beliefs. If it is outside the convex combination it is equivalent to saying that no combinations of agent's beliefs will make it the optimal allocation. Hence, it becomes belief neutral Pareto inefficient Brunnermeier, Simsek and Xoing (2014).

Recall from earlier calculations:

$$V_0^A = \pi[(\pi+\delta)(R_{HH}-K)+(1-\pi-\delta)(R_{HL}-K)] + (1-\pi)[(\pi-\delta)(R_{LH}-K)+(1-\pi+\delta)(R_{LL}-K)]$$

$$V_0^B = \pi[(\pi)(R_{HH}-K)+(1-\pi)(R_{HL}-K)] + (1-\pi)[(\pi)(R_{LH}-K)+(1-\pi)(R_{LL}-K)]$$

$$p_0 = \pi[(\pi+\delta)(R_{HH}-K)+(1-\pi-\delta)(R_{HL}-K)] + (1-\pi)[(\pi)(R_{LH}-K)+(1-\pi)(R_{LL}-K)]$$

If agents have the option of reselling both will want to maximize the present value of the firm. i.e., the problem becomes maximize K*p_0.

Which gives the first order condition:

$$K = \frac{\pi[(\pi + \delta)(R_{HH}) + (1 - \pi - \delta)(R_{HL})] + (1 - \pi)[(\pi)(R_{LH}) + (1 - \pi)(R_{LL})]}{2}$$

However, if agent A or B had sole ownership of the firms and the reselling of shares was not possible, they would invest based on their view of the shares fundamental value. These values are given as.

$$K^A = \frac{\pi[(\pi + \delta)R_{HH} + (1 - \pi - \delta)R_{HL}] + (1 - \pi)[(\pi - \delta)R_{LH} + (1 - \pi + \delta)R_{LL}]}{2}$$

$$K^B = \frac{\pi[(\pi)(R_{HH}) + (1 - \pi)(R_{HL})] + (1 - \pi)[(\pi)(R_{LH}) + (1 - \pi)(R_{LL})]}{2}$$

If we take these values as optimal investment from each agent's perspective then the firm is overinvested from the view of each agent. The amount of overinvestment is given below.

$$K^* - K^A = \frac{1}{2}[(1 - \pi)\delta R_{LH} - \delta(1 - \pi)R_{LL}]$$

$$K^* - K^B = \frac{1}{2}[(1 - \pi)\delta R_{HH} - \delta(1 - \pi)R_{HL}]$$

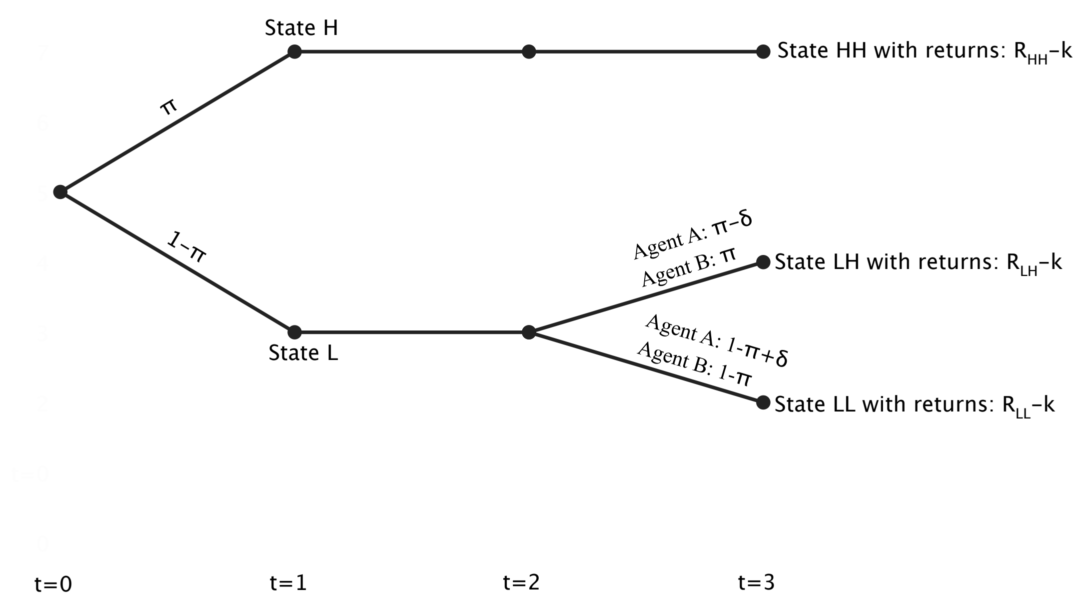
SIRS will have $R_{LL} - K < 0$ while the rest of the states have positive returns. Thus, we can say that the level of capacity investment chosen is greater than optimal from the perspective of agents A and B. Since there is overinvestment from either perspective there must be overinvestment from any convex combination of agents beliefs. Thus, the allocation of capital in capacity investment is belief neutral Pareto inefficient. Also note, the exact amount of overinvestment must be left unstated, unless, judging which agents has the appropriate view of probabilities.

This generalized tree structure can take on more specific forms, to model different scenarios while maintaining our results. The main driving force of this model is an optimistic agent who will buy the shares in the next period. The agent who is optimistic may become a pessimist next period, or remain an optimist. For example if agent A is always optimistic, agent B will agree to maximize the present value of the returns and then sell all shares to agent A. This will leave agent A with sole supply of shares in an overinvested company. This dynamic will be shown as a numerical example in the next section.

An important variation to the tree structure that should be noted, is the structure described in Crean and Milne (2015)[43], see figure 7. This is the main tree used to describe the SIRS process and credit risk that can occur. Modeling this is accomplished by setting $R_{HH} = R_{HL}$, note that agent B does not believe, while A does believe, that the firms are overvalued (agents are now divergent in expectations and beliefs). B is viewed as an irrationally exuberant investor in this case and agent type A is a rational agent. Hence, this allocation remains Pareto inefficient and there is overinvestment in capacity if and only if one assumes that agent B is incorrect in his views. Further, agent A will buy the asset at a greater price than what he believes the fundamental value to be, indicating an asset price bubble.

[43] In Crean and Milne (2015) this tree is displayed as Figure 4.

Figure 7



Lastly, examining the price of the default option, A will underprice the risk since he believes that he will be able to resell the option in the event of state L to agent B, who is more optimistic. This shows J&T and Merton models underprice the risk. These dynamics are shown below and numerically in the next section.

One can show in this case;

$$V_0^A = \pi[R_{HH} - K] + (1-\pi)[(\pi-\delta)(R_{LH} - K) + (1-\pi+\delta)(R_{LL} - K)]$$

$$V_0^B = \pi[R_{HH} - K] + (1-\pi)[(\pi)(R_{LH} - K) + (1-\pi)(R_{LL} - K)]$$

$$p_0 = \pi[R_{HH} - K] + (1-\pi)[(\pi)(R_{LH} - K) + (1-\pi)(R_{LL} - K)]$$

$$K^{***} = \frac{\pi[R_{HH}] + (1-\pi)[(\pi)(R_{LH}) + (1-\pi)(R_{LL})]}{2}$$

$$K^{A} = \frac{\pi[R_{HH}] + (1-\pi)[(\pi-\delta)(R_{LH}) + (1-\pi+\delta)(R_{LL})]}{2}$$

$$K^{B} = \frac{\pi[R_{HH}] + (1-\pi)[(\pi)(R_{LH}) + (1-\pi)(R_{LL})]}{2}$$

$$K^{*} - K^{A} = \frac{1}{2}[(1-\pi)\delta R_{LH} - \delta(1-\pi)R_{LL}] > 0$$

$$K^{*} - K^{B} = 0$$

In this model of the SIRS agent A is willing to pay more than the fundamental value to purchase the stock because of the resale option. Also since agent B is irrationally optimistic in the low state, agent A will sell their shares to agent B in state L. This causes agent A to be willing to invest more in capacity to maximize potential resale value. This will lead to overinvestment in the firm from the perspective of the rational (correct) agent. Also since the agent A views that he can resell in the defaulting state to agent B, then the risk in this model is being underpriced by the Jarrow and Turnbull (1995) method. One can also see that all of these effects grow with the amount of belief dispersion (irrational optimism) in the system.

This section has shown, in a very simple, and easy to generalize model that firms in an SIRS industry can have overinvestment and can generate asset price bubbles. They are driven by the dispersion of the returns in different states and by the degree in which the investors disagree. Also, shown in this model is that the resale option decreases the amount of down side risk exposed to the less optimistic investor, thus, underpricing the amount of risk to which the economy is exposed. These effects can have very harsh consequences on an economy. Only a small amount of belief dispersion is needed for large bubbles and underpricing of risk. These points are illustrated through numerical examples in the next section.

Numerical examples

In this section, some numerical examples are used to illustrate the events described in the previous sections. Specifically, the examples will show the asset prices being higher than fundamental values indicate an asset price bubble, the overinvestment in the firm's capacity and the underpricing of risk for the economy. Investors speculating on future demand, drive these results.

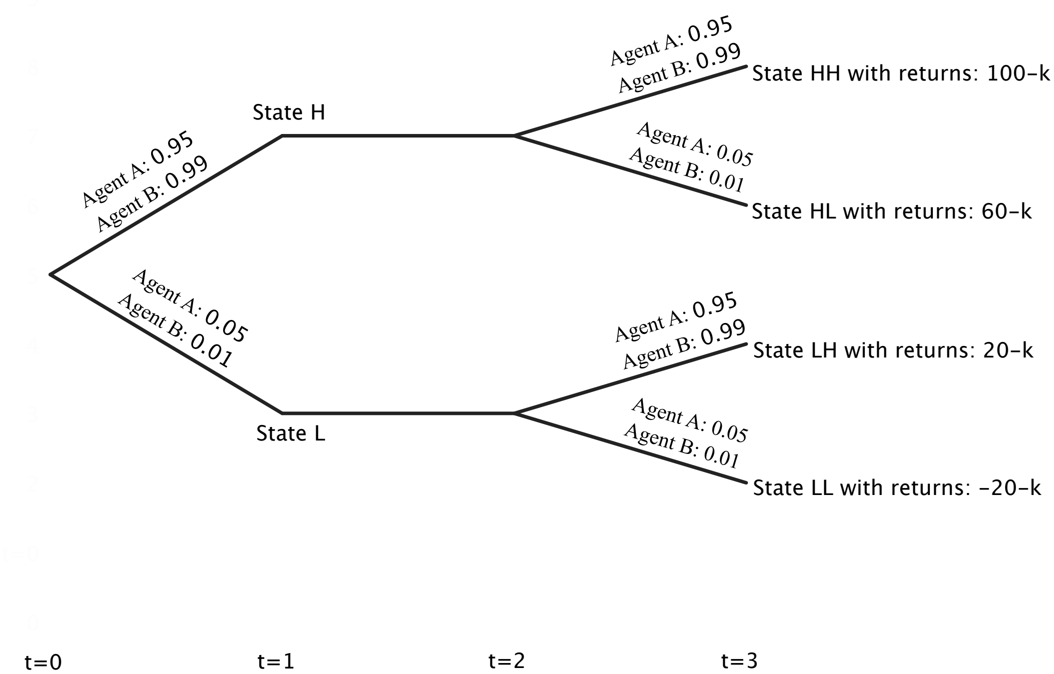
In these examples I move away from the Brunnermeier, Simsek and Xoing (2014) belief structure where the investors are unbiased in expectation and have divergent beliefs. Instead in these examples there will be one optimistic investor and one pessimistic investor. The optimistic investor is assumed to be irrationally optimistic while the pessimistic investor has the true probabilities of states. This could be interpreted, as the pessimistic investor believes demand crashes are possible, while the optimistic investor is using forecasting techniques to generate his/her belief from a data source without large demand shocks. Thus, the optimist will believe that the high demand cases will occur with high probabilities and the low demand cases will rarely occur (if at all).

The reason for this change in structure is to demonstrate one extra generalization in the tree and show how compatible the previous section is with the analysis of Crean and Milne (2015).

Example 1:

This example repeats the case described as above where agent A correctly believes that there is a 95% chance of the demand in the next period being high and agent B believes that there is a 99% chance of demand being in a higher state next period. Since there are a sufficiently high number of agents of type B belief they are able to influence and set the price for the asset. The returns given each state are

Figure 8



given in the figure 8 below.

Then one can find prices, for each type of agent's valuations, and levels of investments, these values are given below.

$V_0^A = 94 - K$ $\quad$ $V_0^B = 98.8 - K$ $\quad$ $p_0 = 98.8 - K$ $\quad$ $K^* = 49.4$

$K^A = 47$ $\quad$ $K^B = 49.4$ $\quad$ $K^* - K^A = 2.40$ $\quad$ $K^* - K^B = 0$

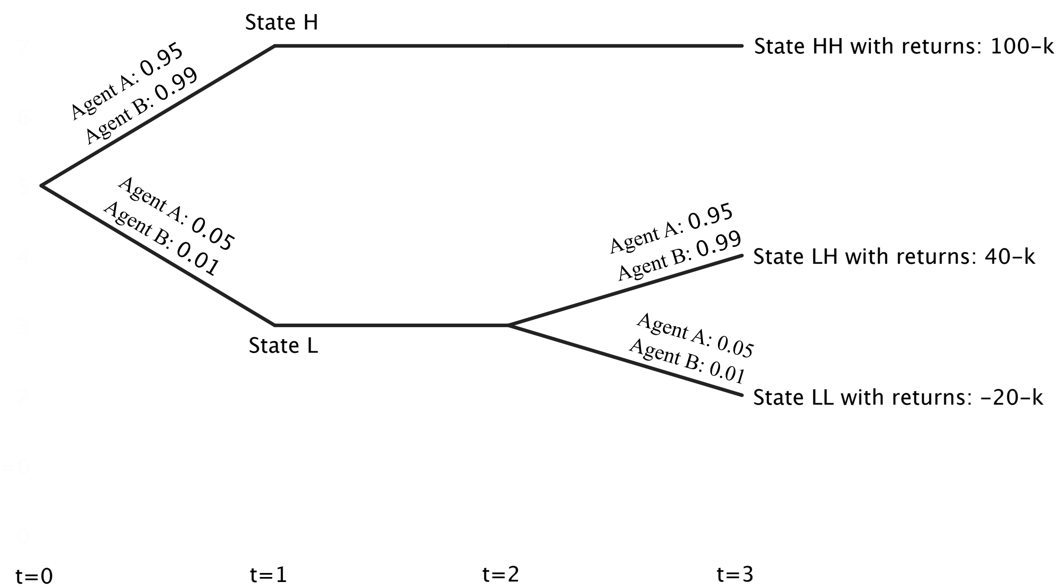
$p_{0-}V_0^A = 4.8$ $\quad$ $V_{0,LL}^A = -0.1735$ $\quad$ $V_{0,LL}^B = -0.00694$ $\quad$ $p_{o,LL} = -0.00694$

Keeping in mind that agent A's views reflect the actual nature of the economy, the prices of this model deviate \$4.8 above the fundamental values indicating a price bubble. Also, the difference in investment between the equilibrium and the socially optimum is $2.4, which is significant considering this represents a nearly 5% deviation from the current investment level. Lastly, the level of risk in the economy is being greatly underpriced. The price of the risk is determined by the investor who is most optimistic about the defaulting loss case, since the optimistic investor in this case believes that this event is 25 times more rare than actuality this model ends up pricing the risk too low by a factor of 25.

Example 2:

In this example, we use the framework and tree diagram used in Crean and Milne (2015). The economy is either in a high or low demand state after one period. If a low state occurs then the demand can recover slightly or become much worse. The dynamic can be shown in the tree diagram of figure 9. In this case agent A correctly assumes that there is a 95% chance demand will shift up in each state. Agent B foolishly believes there is a 99% chance of an upward shift in demand in each state. This can be viewed as an agent who believes a favorable economy will occur with almost certainty. If state L occurs they believe the economy will recover with almost certainty, possibly from a lack of experience dealing with market crashes in the past.

Figure 9



With this framework in place one can solve for prices, valuations and investment levels. The exact figures are given below.

$V_0^A = 96.85 - K$ $V_0^B = 99.395 - K$ $p_0 = 99.395 - K$ $K^* = 49.6975$

$K^A = 48.425$ $K^B = 49.6975$ $K^* - K^A = 1.2725$ $K^* - K^B = 0$

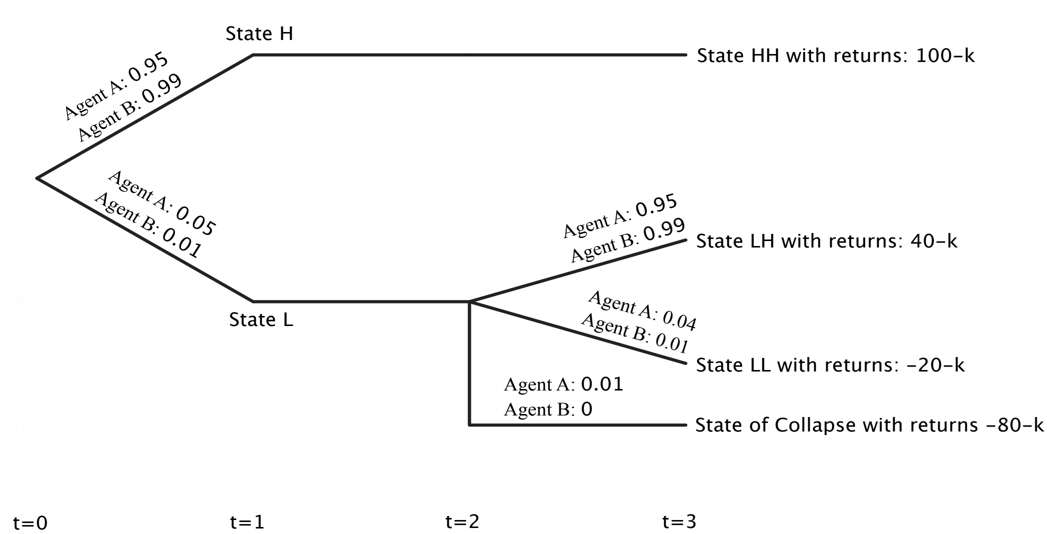
$p_{0-}V_0^A = 2.545$ $V_{0,LL}^A = -0.1742$ $V_{0,LL}^B = -0.006969$ $p_{o,LL} = -0.006969$

The same facts emerge in this example as in the earlier examples. There is \$2.545 asset price deviation from fundamental values and there is overinvestment in the firm by \$1.2725. To see the underpricing of downside risk consider that the market price for the loss in state LL is \$-0.006969 compared to an actual value of \$-0.1742. This difference comes from the agent who sets the price for the risk believing the event is 25 times rarer than reality, resulting, in the underpricing of risk by a factor of 25. Although these results seem like small overinvestments the difference makes for over 2.5% overinvestment, which would be a very large sum for many industrial projects.

Example 3:

Similar to the example above with one key twist, in the event of state L, there are now three possibilities; demand recovery, demand falls more, and a complete demand collapse. Agent B has the same probability distribution as before, meaning they perceive that the crash happens with a probability of zero. This could be explained by agent B forming his belief based on past market data where there is no crash. Hence the data reports the probability of a crash to be zero. Agent A has the true belief structure giving a 95% chance of demand moving higher and in state L gives a 4% chance of demand falling and 1% chance of demand collapsing. This is represented in figure 10.

Figure 10



With this structure in place the valuations of agents, prices, and investment levels are evident. The values of which are given below.

$V_0^A = 97.315 - k$ $V_0^B = 99.494 - K$ $p_0 = 99.494 - K$ $K^* = 49.474$

$K^A = 48.6575$ $K^B = 49.747$ $K^* - K^A = 1.0895$ $K^* - K^B = 0$

$p_0 - V_0^A = 2.179$ $V_{0,LL}^A = -0.18436$ $V_{0,LL}^B = -0.0059747$ $p_{o,LL} = -0.0059747$

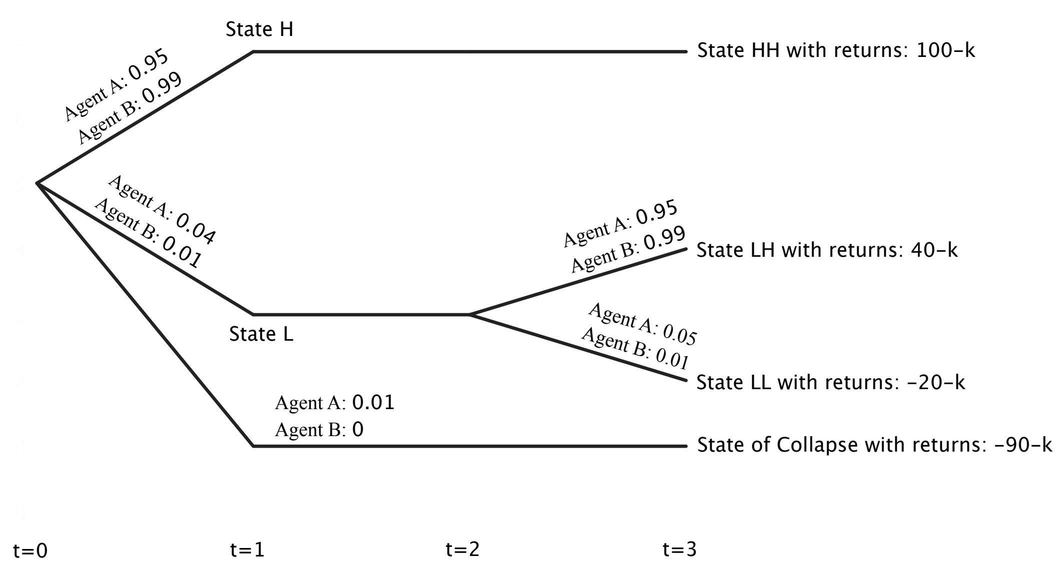
This shows that once again there exists an asset price bubble of $2.179 and there is overinvestment of $1.0895. In this case the pessimistic agent does not perceive the crash to be possible and the risk underpricing effect becomes larger. The risk is priced at $-0.0059747 opposed to the true value of the risk being $-0.18436. This means ignoring the possibility of a collapse in demand raises the factor of underpricing from 25 (in previous examples) to almost 31. Despite the probability of a crash only being 0.05% it increases the factor the risk is underpriced by over 5. This illustrates the dangers of using market data to predict risk, when the data may not accurately describe the true probability.

Example 4:

This example is different from the above example in one subtle way. The collapse in demand occurs directly after the capacity investment is made. This promotes two changes. First, based on the structure of the tree the probability of collapse is increased. Second, the nature of the collapse will be different. The collapse may happen before or after the production decision. If before, the firms can lower production (to a certain degree) but loses any possibility of earning profits in earlier states. If the crash occurs after, they are forced to produce and sell below marginal cost, but have earned a possible profit in the previous period to lessen the damage. As in the previous case agent B maintains the same probability as the first two examples with 99% chance of a higher demand and a 1% chance of a lower demand in each state, combined with a belief that a collapse in demand is impossible. Once again this can be interpreted as agent B using market data to form a belief when the data does not contain a crash event, or simply having never lived through a market crash. Hence, they assume that the crash is impossible.

Agent A has the true probability with a 1% chance of demand crash, a 4% chance of state L. In this case there is a 95% chance of a high demand and a 5% chance of a low demand. This is illustrated in figure 11 below.

Figure 11



Analyzing this tree structure will give the following valuations, prices and investment levels.

$V_0^A = 95.98 - K$ $V_0^B = 99.494 - K$ $p_0 = 99.494 - K$ $K^* = 49.474$

$K^A = 47.99$ $K^B = 49.747$ $K^* - K^A = 1.757$ $K^* - K^B = 0$

$p_{0-}V_0^A = 3.514 \quad V_{0,LL}^A = -1.516964 \quad V_{0,LL}^B = -0.0059747 \quad p_{o,LL} = -0.0059747$

As before this situation shows a pricing bubble of $3.514, which is the largest pricing bubble of these examples. It has overinvestment of $1.757, which represents over a 3% overinvestment. Most troubling is the dramatic underpricing of the default risk. The risk is priced at $-0.0059747 compared to the risk observed being $-1.516964. Indicating the horrible effects that can occur if the estimates of probabilities are wrong, in terms of the possibility of a collapse in demand.

An argument can be made of the unlikelihood of a 1% chance on a collapse in demand. However the underpricing result still holds with lower probability cases. Further, this demonstrates how problematic forecasting errors can be for the SIRS firms. These examples may be taken a step further. By combining examples 3 and 4 we can have scenarios where collapses in demand could happen initially or after the L state occurs. This would further drive a larger price bubble, overinvestment and underpricing of risk.

Example 5:

The $33 billion Petro Canada project in the Fort Hills oil sands is a current example**.** Using their data on internal rates of return (IRR), and cost projects under different market prices. A simple model can be built to highlight the potential overinvestment in the oil sands[44]. This simple model is a preliminary rough estimate; it remains to do a much more elaborate analysis. The goal of this example

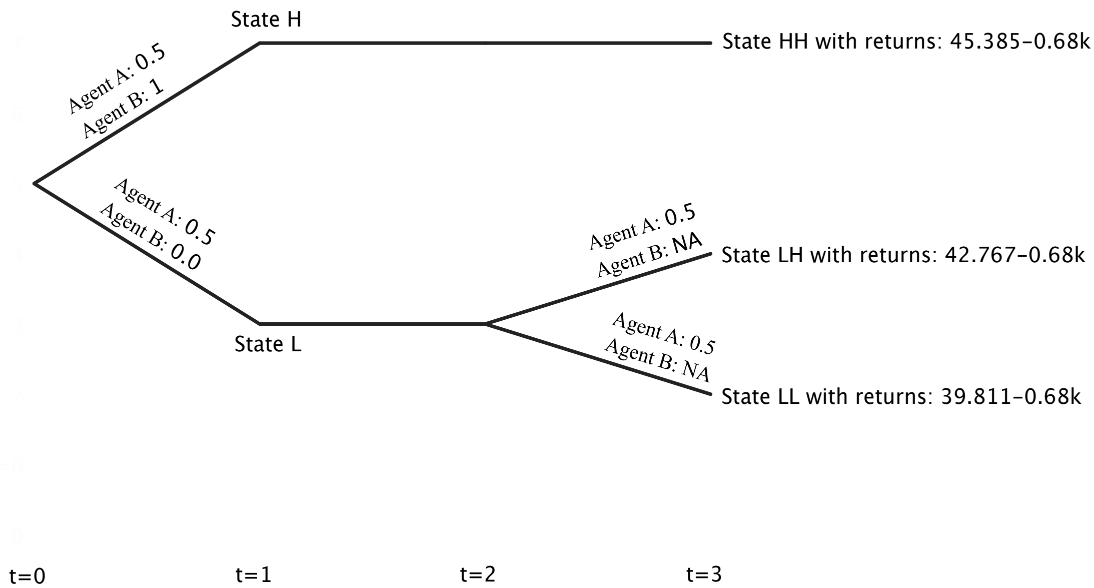
[44] Values taken from "Petro Canada updates Fort Hills oil Sands Costs." In the Oil and Gas Journal.

is to illustrate the models use and to show the scope of the overinvestment that can occur.

A few assumptions are made during this process. First, I assume the discount rate will be constant at 2% (the center of the Bank of Canada's inflation target). I also make assumptions about the agent's belief structures. Next, I assume that given the cost and the discount factor, I can use the internal rate of return (IRR) to find a reasonable estimate of revenue. Lastly, I assume that the firms are able to recover some of the capital costs through selling old equipment, land, etc., once the project is finished, in addition to producing and selling extra oil. Thus firms pay for 68% of the capital cost. This method is crude, however it will serve to illustrate the size of potential overinvestment.

Using these assumptions, the return structures are presented below in figure 12 (revenue and capacity investment are in Billions of dollars). Also contained in this figure are the agent's belief structures. Noting that one agent believes that demand will rise, causing prices to be at $60 WTI with certainty. The other agent is less optimistic, correctly believing that lower demand states are possible. These lower demand states have prices of $50 WTI and $40 WTI. With this setup in place one can solve the model.

Figure 12



$V_0^A = 43.337 - 0.68k$ $\quad$ $V_0^B = 45.385 - 0.68k$ $\quad$ $p_0 = 45.385 - 0.68k$

$K^A = 31.86$ $\quad$ $K^B = 33.37$ $\quad$ $K^* = 33.37$

$p_{0-}V_0^A = 2.048$ $\quad$ $K^* - K^A = 1.50$ $\quad$ $K^* - K^B = 0$

This model demonstrates that the firm (Petro Canada) will invest $33.37 billion in the project ($33.4 billion was announced). Based on agents A's correct beliefs there is a $1.5 billion overinvestment in the project, causing concern in the event of a low demand state. There is a price bubble in existence from the perspective of Agent A. While this model makes many simplifications, it shows the large scale that these overinvestments can have. Also noting that a more generalized structure may be implemented in order to give more accurate estimates of the overinvestment.

Note that there is a $1.5 billion overinvestment on a 33 billion dollar project. By linearly extrapolating this to the 270.4 billion dollars of proposed projects, this could lead to a total overinvestment estimate of $12.1 billion (note that this is a very simple estimate). Also, note that these were the only numbers that were accessible in the time period for this thesis. If one had project estimates before the collapse in oil prices, the firms would likely not be considering price falls to $40 WTI giving the possibility of even greater overinvestments.

These examples illustrated the consequences of these SIRS events. The next section begins with the goal of showing possible indicators of a SIRS event.

Indications of Crises

With the serious consequences of these SIRS crises there is great pressure for policy makers and bankers to identify potential future crises. Unfortunately this is not easy to do. There have been efforts to empirically test stylized facts about bubbles and study potential policy choices. However, this remains a large and unresolved area of research.

The largest problem in detecting a possible bubble event is one is unable to accurately measure the fundamental value of an asset, only the price is observed. Further if a price bubble is in existence it is extremely difficult to forecast when the bubble will burst, as much of the research being done on this area is ex post. Another hurdle is that belief disagreement is difficult to measure, although research is being done in this area. In the SIRS example the disagreement comes from predictions of future demand, which, is not observable to the bankers and policy makers. At best they can employ strong forecasting techniques to achieve their own estimates of future demand.

With these events being difficult to forecast, best practice of banks and policy makers is likely to robustly stress test for the possibility of these events. These tests should include events that seem unlikely, but not impossible to occur. Potential scenarios need to include large rises in unemployment in a region to stress test housing SIRSs[45]. For the commodity market one should include events such as large falls in global demand. Consider, the case where commodity demand declines due to China reducing their demand for building and industrial materials. We have seen this over the last two to three years.

The remainder of the section will be laid out as follows: a brief look at potential indicators of a bubble based on the stylized facts introduced in the literature review; and a call for the need of higher levels of stress testing.

Recall two of the stylized facts about bubbles: they are accompanied by frenzied trading and they coincide with technological innovation, or political maneuvers. The innovation acts as a source for the agent's disagreement, which is necessary for the formation of the bubble. Xiong (2013) argues that bubbles observed in the past have all occurred with excessive trading volume. These facts offer hints of how one could possibly gain an indication of potential SIRS events.

There have been several papers showing the relationship between belief dispersion and trading volume Kandel and Pearson (1995) and Carlin, Longstaff,

[45] As done in Mortgage Insurance as a Macroprudential Tool: Dealing with Risk of a Housing Market Crash in Canada by Thorsten V. Koeppl and James MacGee

and Matoba (2013) are two examples. Further, there have been several papers discussing the joint occurrence of excessive trading volume and asset price bubbles: Xiong and Yu (2011), Mei, Scheinkman, and Xiong (2005) and Carlin, Longstaff, and Matoba (2013). To take this analysis a step further Carlin, Longstaff, and Matoba (2013) have shown over 1993-2012 that there are large increases in trading volume prior to crises.

This can be treated as evidence that a large increase in trading volume accompanied by large increases in the price could suggest a potential crisis is emerging. Hence, one can justify the use of empirical techniques analyzing trading volume along with prices. Observe that this is not a settled field and the use of empirical techniques focusing on volume and price variables is an area, which shows potential. Much work is still required on the empirical side of asset price bubbles and SIRS industries.

If one were able to predict a SIRS event, bankers and policy makers would have choices on the optimal course of action. I do not recommend policies here, but readers are referred to Xiong (2013), Scherbina (2013), and Brunnermeier and Oehmke (2012) for policy discussions.

As a last point, many of these collapses in demand occur sporadically. Thus the data samples used by many institutions will often not contain these collapses. This means that many forecasting techniques using market data will not predict the rapid fall in demand. Thus if policy relies only on this technique it will not accurately predict and acknowledge the crisis states that the policy makers and bankers aim to avoid. To highlight this point, consider the Bank of International

Settlements publication of 2015. They urge the use of market observed spreads and market implied recovery rates, in addition to calibrating to market implied parameters[46]. This will likely not avoid the risk from SIRS for the reasons discussed above.

To correct this fault in market implied data banks, policy makers should adopt a practice of stress testing these sectors and banks for the possibility of large collapses in demand. Doing these stress tests in multiple industries at once is important, since recalling from the SIRS theory in Crean and Milne (2015) the major crises often happen when subgroups of SIRS have severe declines in demand. Fostel and Geanakoplos (2008) offer support for this by creating a model where a downturn in one industry can cause downturns in others. This opens the possibility for multiple SIRS 's defaulting. It is crucial to have stress tests implemented assuming very severe drops in a few SIRS industries simultaneously.

This section has illustrated a few points about the forecasting of SIRS crisis and potential problems occurring in the future. We can reasonably expect the crisis to follow the stylized facts of price bubbles. Thus, it will likely have high trading volume along with the rapid rise of prices prior to the crisis occurring. Robust stress testing will be required in order to be prepared for the next crises. However, the biggest take away is how much more research is needed for forecasting bubbles and SIRS crisis, policy options, and stress testing methods to accommodate these facts. Many of the current techniques are inadequate to forecast and solve these crises.

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[46] See Basel Committee on Banking Supervision July 2015 page 3 and 4.

Conclusion

The SIRS firms described in this paper have been shown by Crean and Milne (2015) to cause the majority of loan losses in each of the recent crises. This combined with the nature of overinvestment and bankruptcy observed in bubbles provides an incentive to dedicate effort to studying this recurring problem. Further, one can find a recurring theme of industries in financial trouble with excess capacity.

I have introduced a modified framework of the SIRS industries model as described in Crean and Milne (2015). With agents trading equity shares based on what they perceive potential demand to be in the future and a cumulative return structure. This can provide the opportunity to generalize to much broader and more realistic scenarios, as in Crean and Milne (2015).

The models introduce the idea that differential opinions cause asset price bubbles in the equity shares of the company. These bubbles can cause overinvestment in firm's capacity, since the higher than fundamental share values provides a company with a source of inexpensive capital. This will raise the level of investment in capacity. Higher investment in capacity starts the scenario of the SIRS crisis where companies have large losses along with chronic overcapacity. Currently we see a number of examples of these SIRS, ranging from real estate markets to mining and automotive sectors.

In addition to the effects listed above, a major consequence of these models is the most optimistic investor in each state sets the price, giving rise to the Jarrow and

Turnbull (1995) and the Merton (1974) models underpricing credit risk. This causes the model to take on more downside risk than it would otherwise, setting up the economy for heavy losses in low demand states.

A potential reason for the repeated nature of these crises is the use of market data in order to try to estimate these downside risks. However, if the data used for forecasting does not include a demand collapse, the estimate from the forecast will underestimate the probability of the collapses occurrence. Thus, it requires very robust standards of stress testing for possible down states. These cases should include crashes in SIRS industry demand, as well as crashes in related SIRS industries.

How bankers and policy makers handle these issues remains unclear. The one thing that should be agreed upon is the need for a greater focus on stress testing these possible events. This will better prepare them for the possible consequences of a future collapse of a SIRS industry.

Lastly, there is a definite need for more study in this area. Only when greater knowledge is gained can we hope to prevent the repeated occurrence of these SIRS events. If we do not learn from these events, we will repeat them.

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