Economic Transition Management in Iranian Cement Industry

Navid Ghaffarzadegan
navidg@gmail.com
Rockefeller College, SUNY at Albany, USA

Amir T. Tajrishi
amir_tajrishi@yahoo.com
Cement Investment and Development Company, Tehran, Iran

Niyousha Hosseini
niyoush@gmail.com
Rockefeller College, SUNY at Albany, USA

Abstract:
Last decade, a lot of countries implemented a transition policy from centrally planned command economies to market economies, while experiencing different socio-economic side effects. After these years, it is still an important issue in the countries which are not completely adjusted to market economy style, to manage the transition process in order to experience less wild fluctuations in prices. This paper represents recommended policies for Iranian Cement Industry which will deal with economic transition in near future. Using a System Dynamics approach, this paper gives some insights into analyzing similar economic policy problems.[1]

Keywords: economic policy, market economy, command economy, transition management, system dynamics

1. Introduction

Last decade, a lot of countries, especially the former communist ones, managed a transition from centrally planned command economies to market economies. After these years, it is still an important issue in the countries which are not completely adjusted to market economy style, to manage the transition process in order to experience less socio-economic side effects.

One of the major sources of socio-economic side effects is price dynamic behavior in transition process. As governments usually set prices lower than their equilibrium states, transition to market economy in which price will be set in the market, creates wild fluctuations in price. In a simple word, when government set a price lower than its equilibrium state, there is a gap between supply and demand, and when government starts the transition, it takes time for supply and demand to approach to their long term equilibrium state. In this period, oscillating price gives wrong signals to supply and demand, usually, exacerbating the situation. Wild price fluctuations are not desired as they can affect other prices in short term, make social complains and restraints, and make the whole transition project fail. As a result, managing transition process in order to damp wild fluctuations in price is very crucial.

Price dynamics is studied by different economists using a classical approach known as cobweb model. Cited by Meadows (1970), cobweb model was first developed by Ricci,

[1] We acknowledge supports of Iranian Cement Investment and Development Company (CIDCO) and especially Mr. Hafez Kamal Hedayat, CEO of the company. All errors are exclusively the responsibility of the authors.

Schults and Tinbergen all in 1930 and mathematically enriched by Nerlove in 1961. In essence, economists assume demand as a function of current price, and supply as a function of lagged price. These two basic assumptions result an equation for price depended on initial price, supply elasticity and demand elasticity. A simple version of the model suggests that price oscillation converge (diverge), if supply is more (less) elastic to price than demand.

Sterman (2000, p.798) argues that cobweb models are unsuitable for serious modeling of market dynamics. Neglecting stock flow structure of the market, formulating in discrete time, wrong results for oscillation periods which is usually less than what occurs in real life and weakness in explaining multiple oscillatory periods observed in many industries are some of the cobweb models pitfalls.

Price and production oscillation are also studied by system dynamists. In one of the classical System Dynamics works, Meadows (1970) developed a model of commodity price cycles for live stocks. His model shows how some small changes in the system lead the whole system to oscillate. Then he customized his model for simulating oscillation pattern in hog price behavior, showing the model generates the actual observed behavior.

Meadows' notion has been used and developed by other system dynamists. Sterman (2000, p.p. 791-798) introduced a generic model of supply and demand and applied it to study price cycles in pulp and paper industry. Jones et. al. (2002) discussed capacity sustainability in the sawmill industry in the northern forest by developing a resource-price model, and discussing weak effects of price signal on sustainability of forest resources. Mashayekhi et al. (2006) developed a set of supply demand dynamic models and used them in an interactive electronic environment as a tool to teach Micro Economics.

Sterman's generic model explains common origin of the chronic fluctuations in commodity industries. Existence of supply and demand balancing loops with different delays (e.g., delay in utilization change and in capacity improvement) causes price to oscillate. Mashayekhi et al. also discussed how different delays could be considered in supply demand structure. In Mashayekhi's set of supply-demand models, delays are added to both supply and demand related loops, showing how they could cause oscillation.

These efforts show, while there are always some reasons for short term changes in demand and supply, market reacts to those changes exacerbating instability and causing cyclical oscillation in demand and supply. Those reactions are affected by different characteristics of a market such as time needed to switch to new products or to increase supply. Sterman (2000, p.p. 792-793) discusses that hog price and production fluctuate roughly a 4-year period, while cattle cycle is about 10-12 years and copper cycle is about 8-10 years. The difference in oscillation characteristics declares different structures and time delays in those markets.

All of these SD models are about market economy in which price can be set by a kind of negotiation in the market. Actually, this is not always the case. In a command economy, pricing mechanism is totally different and prices are usually set by the government. As we mentioned, when a government set a product price, it influences the level of supply and demand. The mechanism which makes these two equal, is a black market.

In SD models, structures act as an oscillation generator, and oscillation is usually initiated by some random or exogenous factors. In Meadows' model, a step rise in demand make price oscillating, and in Sterman's pulp and paper case, the oscillation generator structure is affected by some random external effects. But, external effects, which initiate (not generate) oscillation, could also change a structure to an oscillation generator one. This change can also initiate oscillation in the system. This could happen as a result of economic transition from command economy to market economy, which influences pricing mechanism. None of previous SD works have studied such a situation.

In this paper, we study Iranian Cement Industry which will experience a structural transition from command economy to market economy in near future. Based on this study, a System Dynamics model will be developed and simulated. Considering Forrester's concern about modeling a family of systems rather than a specific situation (Forrester 2003), the developed model is generic, belongs to the family of commodity market systems, but is tailored for analyzing economic transition in Iranian cement industry. The developed model will be used to test different policies in order to decrease price oscillation and make a smooth progress in cement consuming projects. This paper gives some insights into studying economic transition policies, as well as explaining oscillation generator structure in cement industry. The dynamic nature of the problem and structural driven factors consisting different feedbacks in the system, makes System Dynamics an appropriate method to study this problem.

2. Problem definition

Cement has a low ratio of price to weight. According to this fact, product delivery cost is a large portion of cement production finished cost. Products with such a characteristic give competitive advantage to local producers as they face lower costs of transportation. Figure 1 shows that less than 20 percent of globally produced cement is traded internationally, and while cement consumption is increasing smoothly (6 percent per year increase in average), international cement trade change is almost the same (5.3 percent per year increase in average).

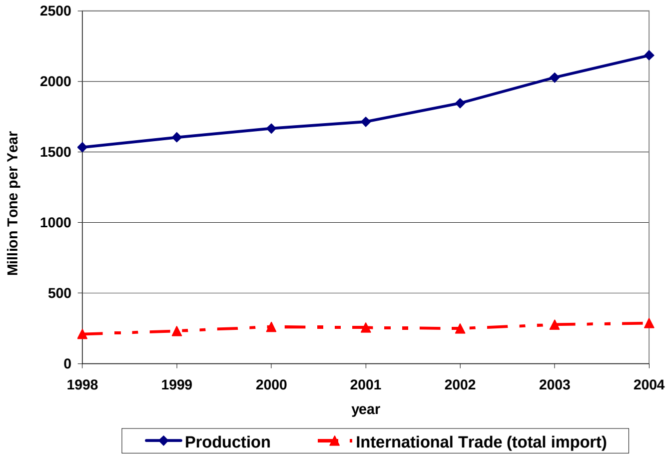

Figure 1: Comparison of global production and international trade of cement in recent years - (International Cement Review, 2003, 2004, and 2005)

In Iran, cement industry is faced with problems of command economy. Since 2000, cement price has been set by government below the equilibrium level. This has caused a gap between demand and supply. Low level of price, on the one hand, has caused over demand, as it has made a huge number of projects feasible. Price also has made cement more attractive than its substitutes (e.g. steel). On the other hand, manufacturers, who logically want to maximize their profits, produce much less than what is demanded. Developing new plants of cement factories are not feasible with the current level of price and the current capacity can not produce much more than its current production. Therefore, market faces a gap between demand and supply.

There is a number of unfinished cement factory plants started long time ago, expecting a rise in cement price. The industry is not profitable either to start new factories or to complete the current unfinished plants.

As it is not possible for demand and supply to be balanced in the market, a black market of cement has been emerged and, as we explained before, due to transportation costs, the market is not interesting for foreign producers. While, in 2005, cement price was set around 35 dollars per ton by government, at cement consumption peak (i.e. summer), price increased up to 100 dollars per ton in the black market. Figure 2 shows price trend in recent years.

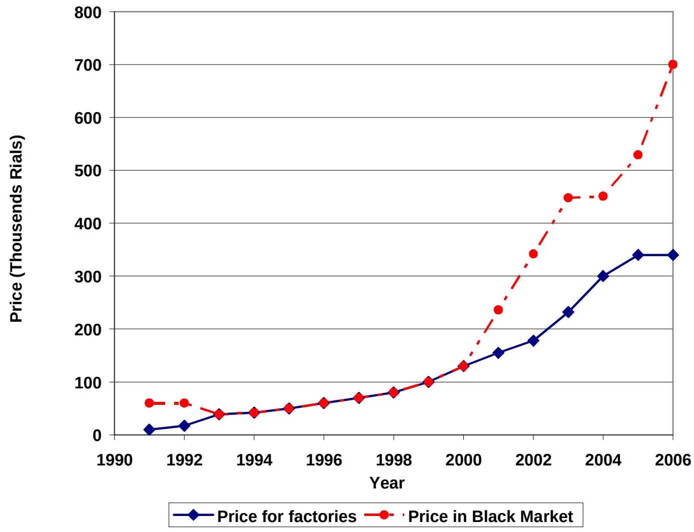

Figure 2: Price trend in cement industry and the effect of government interference in price since 2000[2] (extracted from Iran's Planning and Budgeting Office reports (2006a and 2006b))[3]

At first glance, it seems that government is adjusting the price to the appropriate level and it is the black market price which rises so fast. The misleading point, here, is inflation rate. Considering macro economic condition of Iran, most of these rises are not more than inflation rate. To avoid this misunderstanding, it will be useful to illustrate almost a same graph but with the REAL prices. Figure 3 shows such a graph, considering 1991 as the base year.

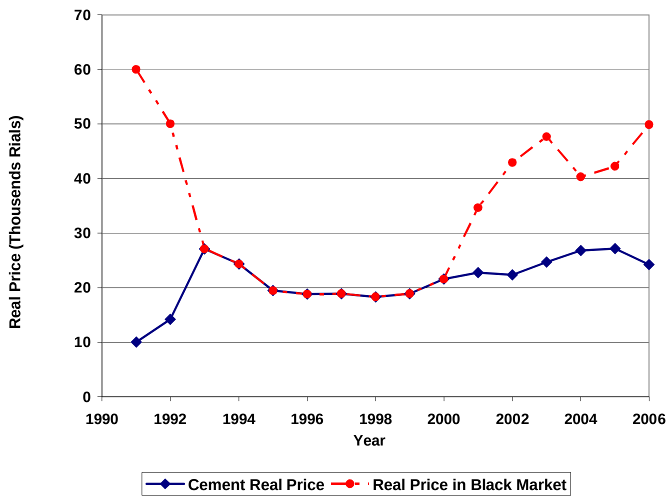

Figure 3: Real price trend in cement industry – Base year: 1991

[2] Before 1993 cement price had been set by the government for a long time.

[3] As a result of lack of data for cement black market price in 2001 and 2002, these two points have been generated by the authors using a liner interpolation between existed data of 2000 and 2003.

There are two major points in Figure 3. First, it shows that when government, in 1993, made cement price free, price increased above the equilibrium state and then converged to it, almost after two years. Second, it shows that in recent years the equilibrium state of cement price is increased. It can be as a result of shift in demand influenced by a rise in oil price and national income or the entrance of Iran's baby boom to 20-30 years interval.

But if all problems can be solved by making the cement price free, why is it still fixed? There are various reasons. Government believes that cement is a strategic product and a rise in its price can cause some other prices to rise (for example price of real estates.[4]) Also, government believes that making the price free and trusting on invisible hand, does not necessarily give us a good transition path. The price can fluctuate wildly and make some side effects on economy. A wild rise in price, also, affects cement consuming projects' progress rate. Social dissatisfactions in the country, which is not desired for any government, will be another consequence of uncontrolled transition.

Manufacturers' union and related lobbies try to encourage government to make the price free and let cement to be sold in Iran's product exchange market, like some others such as steel and copper. But they know that if the transition process is not managed well, government will return to previous stage, fixing cement price, and the whole project will fail. Therefore, it is very important for both government and the whole industry to manage the economic transition.

Considering these conditions, there are two questions: how will price behave after making it free, and what are the appropriate policies to manage transition process in order to decrease wild fluctuations in price. Decreasing the transition side effects on cement consuming projects' progress in demand sector, and decreasing the possibility of over capacity in supply sector are two important concerns in this transition policy.

The important point here is that both questions consider price dynamics rather than the final stage (equilibrium state), and both ask about the transition process between two stages (command pricing and market pricing). In following, we will review briefly our methodology, and then build a system dynamics model to find appropriate policies to manage the transition.

3. Method

This project is an interview-based system dynamics work. In first step, a base model of demand and supply is developed. Then using the base model as a framework, a set of interviews is conducted and the model is carefully disaggregated in order to consider specific characteristics of cement industry. In this project, a set of semi-structured interviews are conducted with eight people; two CEOs of cement companies, two CEO and one MOB of investment companies (can be considered in both sides, suppliers and consumers), one former manager of a major construction project, one former minister of housing, and one expert in product exchange market.

While pure economic approaches are more concentrated on equilibrium stages, System Dynamics gives us the ability to analyze the dynamics of price in this transition. It is the main concern of this project.

[4] Although cement cost is a small portion of finished cost of houses, but at least in short term, a huge rise in cement price can cause some considerable changes in real estate price, due to behavioral issues.

The other point is the importance of using tools and techniques that can be presented and understood in an easier way by executives. As the project questions engaged with executives' mental models, a well developed causal loop model can facilitate learning (Senge 1996).

This model is developed to study the effects of change in pricing structure on price dynamics, so we neglect effects of seasonal changes in cement consumption on price which is almost clearly predictable in this industry (up to 15 percent rise in cement demand in spring and summer comparing to fall and winter). Also, all discussions are about cement real price; however adding a constant and exogenous inflation rate into the model is possible.

In following, first, we explain a base model. Then, in two steps we disaggregate supply and demand sectors and examine model behavior. Finally we test proposed policies in the model.

4. Model

4.1. Base model

A common model of demand-supply-price relation has been used in previous system dynamics works. In these models, considering two balancing loops, a change in price, changes demand and supply, and those two influence price itself (for example see Mashayekhi et al. 2006).

As a matter of fact, it is a model of market economy while in command economy it is the government who set prices directly, and influences both demand and supply indirectly. One may say that government receives a feedback from demand and supply and, sometimes, change the price to fill the gap. Figure 4 shows demand-supply-price relations in a free market (A) and in a command economy (B).

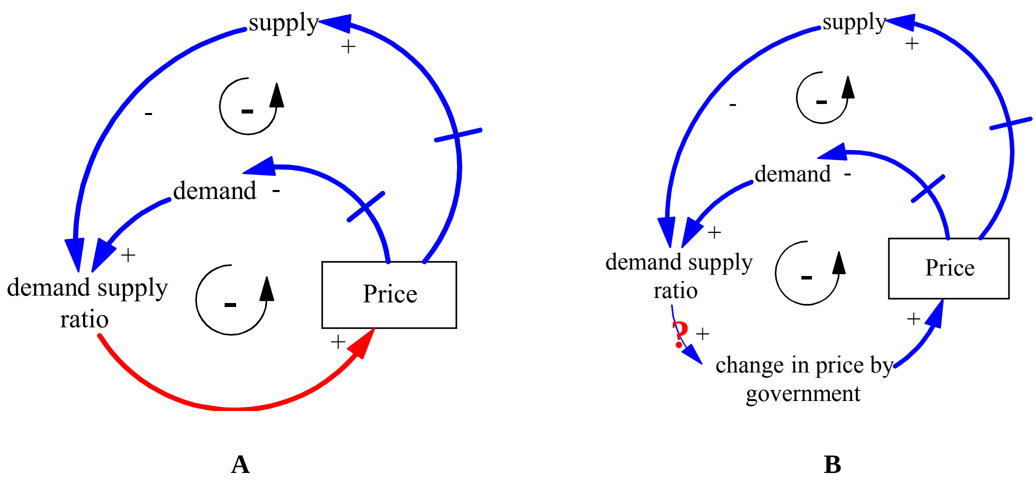

Figure 4: demand-supply-price relations;
A: in market economy - B: in command economy

The important difference between Figures 4-A and 4-B is the difference between their pricing mechanisms. The direct link from demand supply ratio to price, in Figure 4-A, is disappeared or went through government's mental model in Figure 4-B. In this paper, we will study a change in pricing structure from 4-B to 4-A. For this purpose, we will develop a potential model of cement industry in market economy and will study how activation of the link between demand supply ratio and price, i.e. making market free, causes wild fluctuations. In following, we disaggregate supply and demand sectors.

4.2. Supply sector

As we know, price and supply act as a balancing loop; as price increases, desired supply raises and causes the supply to increase. An increase in supply decreases price. In cement industry, there are various ways to increase supply, and usually there is a delay between desired supply and supply.

There are two kinds of typical actions to increase supply: increasing capacity utilization and increasing capacity itself. Like other industries, cement manufacturers indicate that their first reaction to a rise in desired supply is to increase capacity utilization. Considering a constant level of capacity, as they utilize it more, they produce more. The produced cement is supplied to market, and can adjust price in an open market economy. As Sterman (2000) explains, there is a considerable delay for changing capacity utilization. This phenomenon is shown as a balancing loop (B1 in Figure 5.)

The second way that suppliers use to increase supply is investing in capacity development. Cement manufacturers, like other industries develop production capacities to increase supply, (B2 in Figure 5); however, there are plenty of interesting and complicated ways to increase capacity. In following we will discuss those ways.

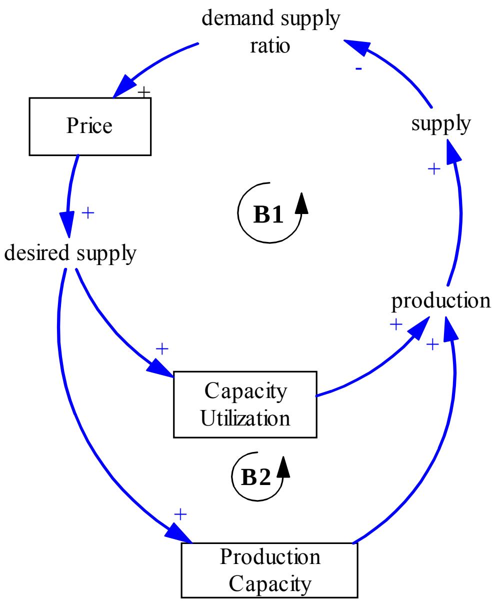

Figure 5 - Two typical ways to increase supply

4.2.1. Capacity development in cement industry

After increasing capacity utilization, manufacturers' second reaction to an increase in price is to complete the current under construction plants, by performing faster, and allocating more resources on semi-completed plants. In fact, there is a number of incomplete capacity development projects, some even completely stopped, and a rise in price will make investors motivated to finish them faster.

Third reaction of manufacturers is to start new capacity development projects. There is an interesting point here, as there are two ways to increase capacity:

- In a more straightforward way, investors (existing companies or new comers) start a new factory or a new plant. In average, it takes four years to finish a plant, and this delay influences price behavior. As we discussed before, projects progression rate falls, as cement price falls.

- There is another way to increase capacity; that is to improve current facilities to produce up to 20 percent more. This is a more common approach in which a factory upgrades some facilities. It usually takes 6 to 12 months, much less than developing a new plant. This reaction comes form the fact that when a factory is constructed, it worth to set some critical equipments, such as boilers, for higher capacity. This will give the opportunity for suppliers to improve their capacity in future with much lower costs, and without changing the critical equipments. So, such an improvement can be done once in a life for a factory. The important point is that plants should be completely shut down while are being improved. Therefore, this strategy leads to a drop in capacity in short term (and a rise in price in a market economy.) Thus, a reinforcing loop appears which exacerbates the lack of supply while decreasing capacity online in short term.

Considering such a phenomenon, we can define a chain of capacity: plants under construction (i.e. projects of new cement plants), capacity not improved (i.e. finished and online plants which have the possibility of improving in future), capacity to be improved (i.e. shut down capacity for the purpose of improving up to 20 percent in capacity), capacity improved (i.e. online plants which have been improved before and there is no possibility of further improvement.) These four stocks are linked as an aging chain (Figure 6) in which we have:

rise in capacity = raise percentage × improving
Capacity Online = Capacity not Improved + Capacity Improved

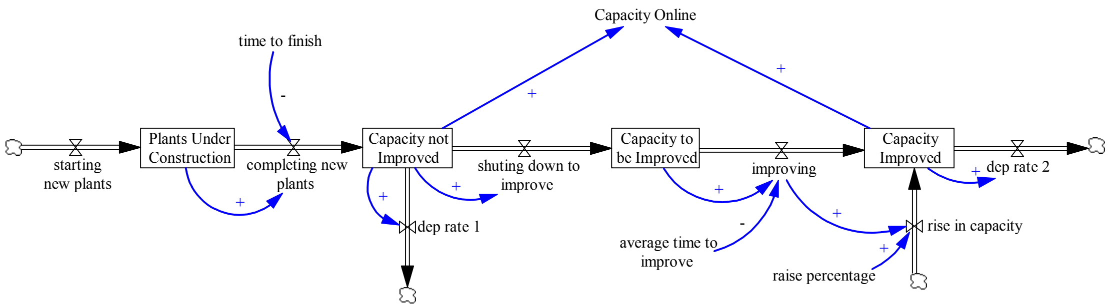

Figure 6 - Capacity aging chain

Time horizon in this model is 48 months, and in such a period, depreciation rate could not affect capacity very much. Cement factories age more than 30 years, and there is no environmental regulations in Iran to limit the use of old factories. So, we neglect depreciation rate outflows.[5]

Using the defined aging chain, we can develop other aspects of supply sector. As we explained, we expect a balancing loop between price and supply through four major ways. Figure 7, a simplified version of supply sector shows those ways in an aggregate structure. This figure shows that a rise in desired production can influence the capacity chain through different ways. Although it is a very simple version of the whole model, it shows that there are different delays in the system, and there is an important positive feedback loop which decreases capacity online, and increases overshoot (R1.)

[5] In a first draft of the model, co-flows were used to model depreciation rates. But the low rate of depreciation did not affect the results in a period of 48 months. We neglect it, to keep the model simple.

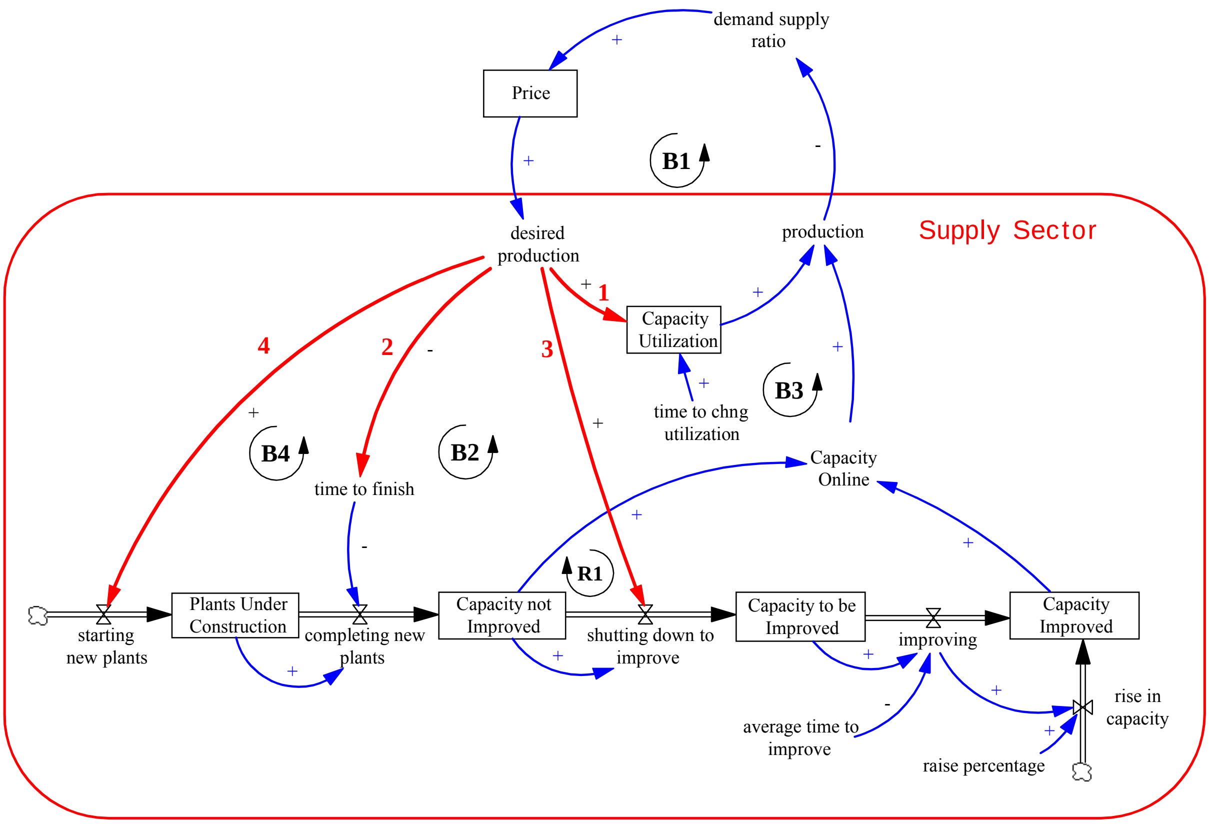

Figure 7: a simplified version of supply sector

Figure 7 is disaggregated to consider the feedbacks people receive from capacity stocks while planning to increase it. In fact, increasing capacity is affected by the current level of capacity and the expected level in future. This also is affected by the desired level of capacity utilization in long term. It maybe expected that people start the needed capacity rationally, predicting the future capacity accurately, but interview results show that it is not usually the case. People are less sensitive about under construction plants for which there is no accurate information, and estimations are mostly based on the other three of the four stocks (Capacity not Improved, Capacity to be Improved, and Capacity Improved). They have just a perception about under construction plants.

4.3. Demand Sector

Disaggregating the demand feedback of the base model gives some more insights into how demand and price affect each other. Usually in System Dynamics models, demand sector is simply modeled by a simple link for price to demand without a considerable delay, or by a backlog affected by price, in which, usually, the time to change backlog is low enough letting the price to approach its equilibrium fast.

In cement industry, cement consuming projects are the drivers of cement demand. These projects include big ticket projects, such as dam constructions, and high way constructions as well as smaller projects such as renovating and repairing houses. In an SD model, different backlogs can be considered for each one, or they can be modeled as an aggregate demand.

The other point is that it takes time for consumers to adjust number of projects to the desired level. Thus, consumers react in two ways: in short term, they may postpone some orders, decrease progression rate, or temporarily hold on some projects. In long term, they can adjust number of projects to the desired level.

Thus, we can say that total cement consumption comes from number of cement consuming projects and demand per project. In fact, adjusting number of projects take more time, but demand per project can be changed much faster. Figure 8 shows demand structure. To keep the model simpler, we use demand with the dimension of "product unit" per "time unit" to formulae the demand sector.[6]

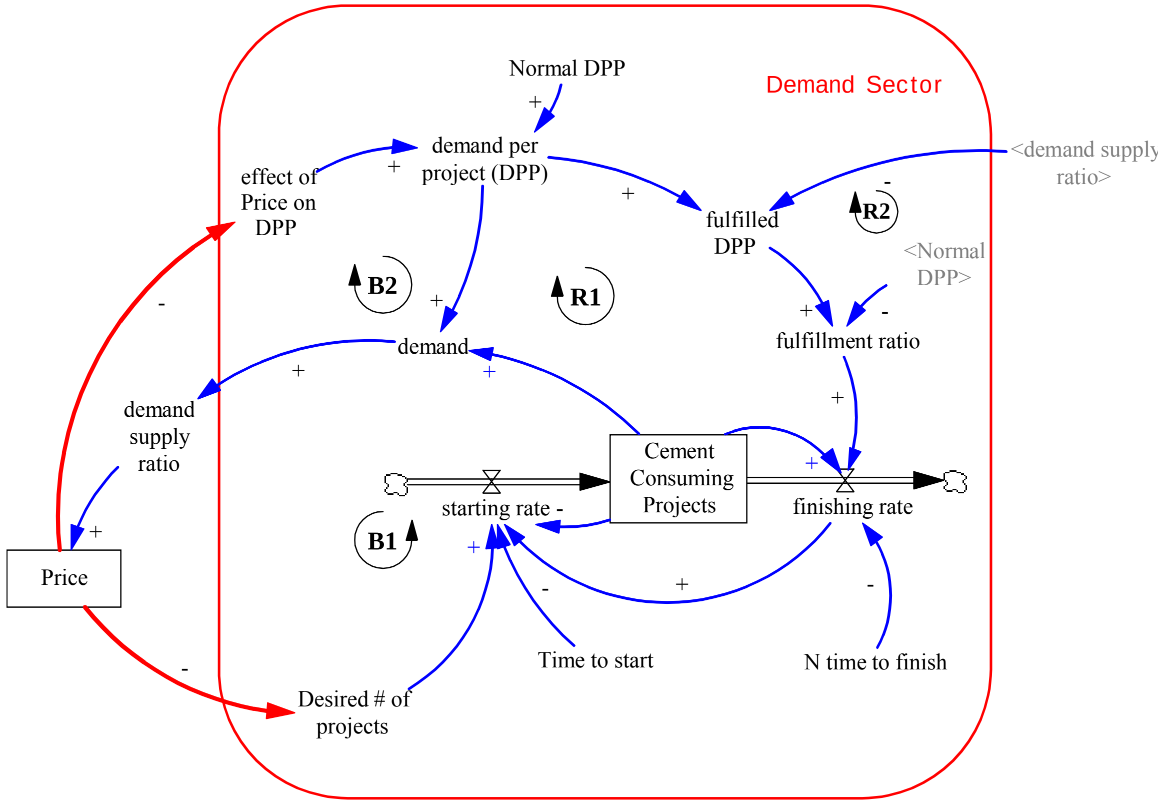

Figure 8: Cement Demand Sector

Cement consuming projects are also affected by cement adequacy. This phenomenon comes from the fact that all orders can not be fulfilled specially in a command economy system in which there is often a gap between demand and supply. Let's define fulfillment ratio as ratio of "fulfilled demand per project" to "normal demand per project." Two feedbacks affect fulfillment ratio. First, as cement demand increases, price rises, and it leads to lower demand per project, and lower fulfillment ratio. Lower ratio affects projects' finishing rate. More projects leads to more demand (R1). And second, as cement demand increases, demand supply ratio rises, and fulfillment ratio drops (R2).

In Figure 8 the link between "demand supply ratio" and "price" is what should be activated to transform the system to market economy.

4.4. The whole model

In our model, supply and demand sectors are connected through price and demand supply ratio. Adding two sectors through demand supply ratio, and completing the model to consider all delays and table functions, the whole model emerges. Also in the whole model, policy making mechanisms, is added. Final model formulas are illustrated in Appendix 1. So, we

[6] Adding backlog(s) has been tested by the authors, and as the time delay to adjust backlogs to the desired demand is low enough, they don't change the results of simulation qualitatively.

want to activate the link from *demand supply ratio* to *change in price*, to study dynamics of cement price in transition process.

5. Simulation Results

Figure 9 shows the simulation result and supports our expectation of a big overshoot in price while approaching to long term equilibrium state. As we discussed before, this overshoot should be controlled, as it makes a huge arguments in the country against the whole process, and there is a possibility of the whole project to fail. Also this overshoot affects other prices in the country especially in short term, which should be avoided by government. The worst thing is the false lessons people learn from such a failure, which will cause cement price to be fixed for a long time.

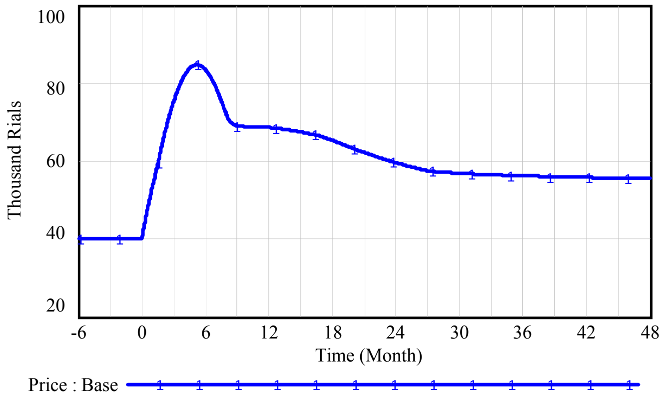

Figure 9: Cement Price with and without R1

Figure 10 shows that how long term efficiency of cement industry will be affected by an overshoot in price. In fact, long term capacity utilization shows how efficient an industry is. This figure illustrates that the price overshoot will give wrong signals to suppliers to start plants which are not feasible in long term. Thus, this overshoot influences cement industries' efficiency for a long period of time, and appropriate policies should be taken to control it.

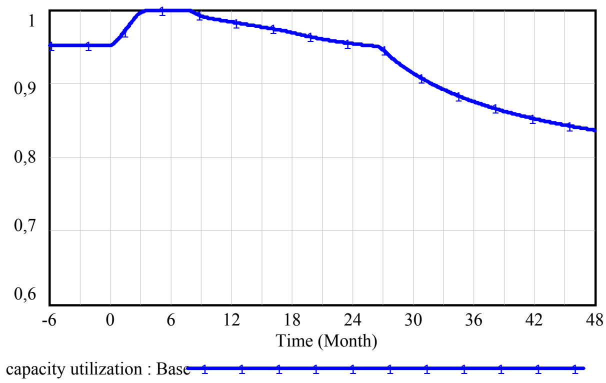

Figure 10: effect of transition on supply sector

Figure 11 shows the other side of the problem, the demand side, by illustrating cement consuming projects finishing rate and fulfillment ratio. As we discussed they are both important concerns from government's perspective. The graph shows the transition solves demand problem after two years.

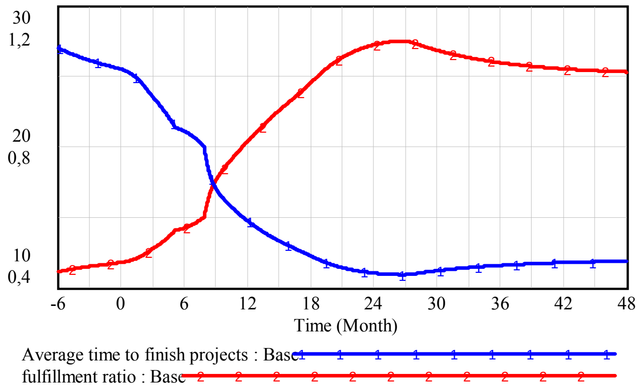

Figure 11: effects of transition on demand sector

We test different policies in order to control overshoot shown in Figure 9, with considering side effects of the policies on capacity utilization (figure 10), average time to finish cement consuming projects and fulfillment ratio (figure 11). In this study, a policy is a set of actions Iranian Government can take in order to control cement price dynamics in transition to market economy. Choosing the appropriate actions in appropriate sequence can produce better results. The possible actions in this study are:

1. *Making price free:* As it is assumed that government is dedicated to take this action, the important point is the time that this action should be taken.
2. *Importing:* As we discussed, cement is a local product because of the cost of transportation. So, in Iran, it is only the government who can import and sell it in a lower price to control price shock. The important point is the duration of importing and resources allocated for such a purpose.
3. *Change in price:* Government is able to change the price before making it free. It could be done in one hectic step or in more steps, and the amount of change is also important.

A policy in this paper is a set of these actions. So, there are a large number of policies can be taken in this transition to manage price dynamics. Six of the most common policies are listed in Table-1.

Policy Actions	**Advocates**
P1: Making price free at t=0, and importing subsidized cement for three months	Manufacturers
P2: Making price free at t=0, and importing subsidized cement for five months in a declining rate	Manufacturers
P3: Making price free at t=0, and lower subsidized importing for nine months	Manufacturers
P4: Adjusting price in two steps, and then making price free at t=24.	Not yet
P5: Adjusting price in one step, and then making price free at t=24.	Not yet
P6: Adjusting price in one steps, making price free at t=24, and very low level of subsidized importing around t=24	Not yet

Table-1: Studied policies

These policies are simulated and the simulation results are shown in Figure 12.

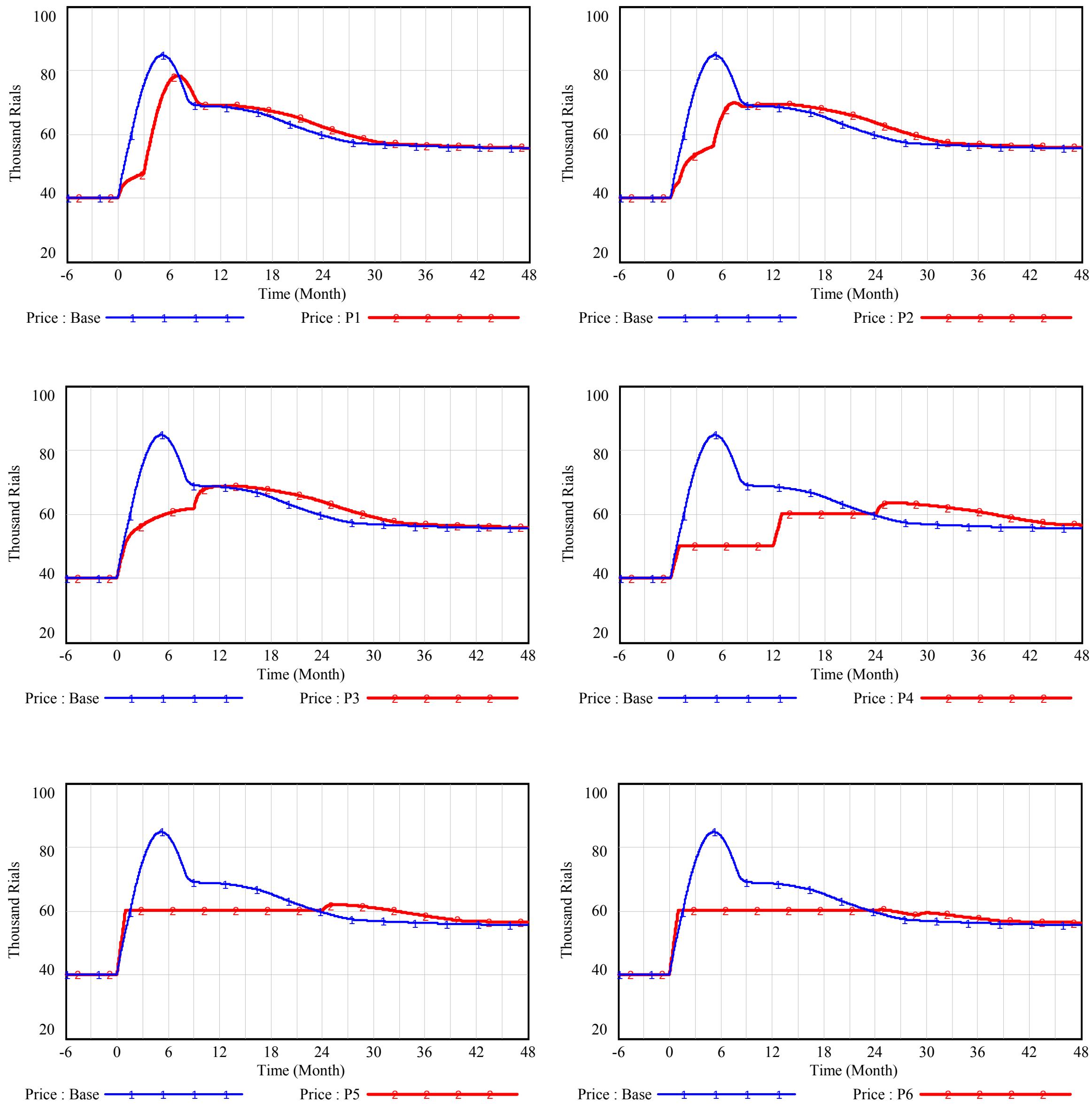

Figure 12 – Effects of different policies on cement price behavior in transition process

Simulation results show that P1, P2, and P3 face some problems in controlling overshoot. This means that in order to be able to control overshoot we need to import for a long period of time, and government resource should be allocated for a longer period of time. The other point is that importing should not damp price rise completely. A rise in price is a signal for suppliers to increase their supply and for consumers to adapt themselves to the new situation. Therefore, if government damps the price rise by importing and subsidizing products, it will just postpone the overshoot. Whenever government finishes its resources, the overshoot will emerge.

In next three policies we have postponed transition in order to decrease supply demand gap before making price free. The main action is increasing price before making it free. The difference relates to steps of price raise. P6 is a combination of price rise and importing policies, however, the amount of needed resources to subsidize importing is much less than what we need in P1, P2, and P3.

In P6, the least popular policy among administrators, government increases cement price hectically, and after an enough period of time which gives the opportunity for supply and demand to be adjusted, government takes the second action, making the price free. The later overshoots will be managed by possible imports. Surprisingly, it needs much less financial resources than what government is expected to pay to control price during transition. Also in P4, we have lessened price overshoots, although it is not completely disappeared. The difference between these two graphs relates to the time we give to supply and demand to adjust themselves to the equilibrium state, and that is the time interval between when we raise price to equilibrium state and the time we make price free.

Considering simulations results, it seems policies P4, P5 and P6 are able to control overshoot. Although simulation results are in favor of the sixth policy, administrators may have difficulties with raising price in one step. In comparison to P5 and P6, P4 lessens the first shock.

Another important point is the effect of implementing these policies on production efficiency in long term (Figure 13). Obviously, it is not desired to meet lower level of utilization in future. In P4 and P6, as we have not increased our capacity more than what we actually need, the long term utilization is close to the desired level (here, 0.9).

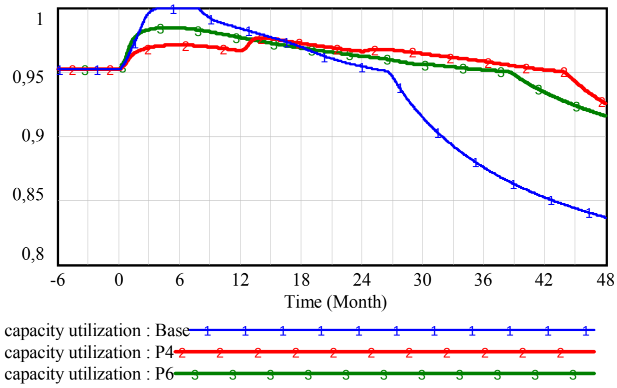

Figure 13: Effect of policies on long term capacity utilization

The final point relates to the demand sector. One of the main reasons of implementing these policies is to facilitate economical growth, and in this problem, it is important to consider the effect of our policies on cement consuming projects. An appropriate policy should not stop or decrease the progression rate of construction projects.

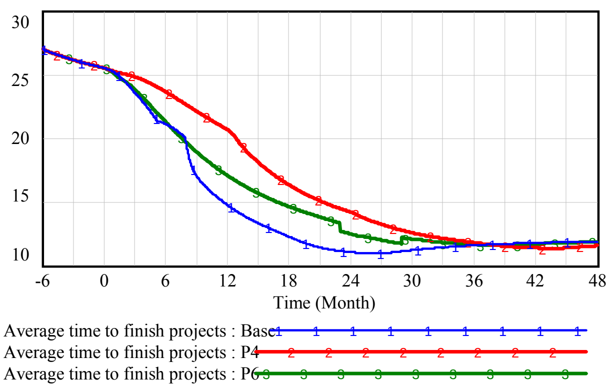

Figure 14: Effect of policies on average time to finish cement consuming projects in demand side

Figure 14 compares "Average time to finish cement consuming projects" in P4 and P6 our base model. The figure shows that demand sector will not be affected very much, and in fact, the transition will be much smoother in these policies, especially P6.

6. Conclusion

Transition to market economy in cement industry will result a big overshoot in cement price. This phenomenon relates to the complicated structure behind demand and supply in this industry which accelerates price oscillations and takes more time for demand and supply to adjust themselves to equilibrium stage. Also, the false signals received from overshoot lead the industry to lower level of efficiency in long term.

Simulation results suggest the following sequentional actions as the recommended policy in order to control cement price overshoot:

1- Increase cement price, in one step, and adjust it to the approximate equilibrium state. (The alternative is to adjust price in two or three smaller steps.)

2- Give enough time to supply and demand to adjust themselves to the new condition, and monitoring changes in production capacities.

3- Provide the conditions needed to import cement.

4- Make cement price free.

5- If it is needed, import cement to adjust price with its long term equilibrium stage.

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Technical Appendix 1

Accumulated Inflation= INTEG (inf rate,1)
Average time to finish projects=Cement Consuming Projects/finishing projects
average time to improve=9
cap to shut down=fsd(new cap needed/Capacity not Improved)*Capacity not Improved
Capacity Improved= INTEG (improving + raise in capacity,45)
Capacity not Improved= INTEG (completing new plants-shutting down to improve,25)
Capacity Online=Capacity Improved + Capacity not Improved
Capacity to be Improved= INTEG (shutting down to improve-improving,2)
capacity utilization=SMOOTH(fu(desired production/Capacity Online),0.5)
Cement Consuming Projects= INTEG (starting projects-finishing projects, 150)
chng in price= percentage of chng in price*Price/T to chng price*STEP(1, 0 +(switch to P4+switch to P5+switch to P6)*24)+switch to P4*(STEP(10,0)-STEP(10,1) + STEP(10,12) - STEP(10,13))+(switch to P5+switch to P6)*(STEP(20,0)-STEP(20,1))
completing new plants=Plants Under Construction/Normal time to finish*speed multiplier
demand=Cement Consuming Projects*Normal demand per project*effect on demand per project
demand supply ratio=demand/supply
"desired # of projects"= fs(NP/Price)*ND
desired capacity=desired production/desired level of utilization in Long term
desired level of utilization in Long term=0.9
desired number of new plants=(new cap needed-cap to shut down)
desired production=fs(Price/NP)*NS
DO cap ratio=desired capacity/Capacity Online
effect on demand per project=fef("desired # of projects"/Cement Consuming Projects)
f([(0,-0.4)-(4,1)],(0.25,-0.12),(0.5,-0.1),(0.8,-0.05),(1,0),(1.2,0.05),(2,0.1),(4,0.12))
f adequacy([(0,0)-(10,10)],(0,0),(1,1),(5,1))
fef([(0,0)-(4,2)],(0,0.5),(0.5,0.55),(0.75,0.6),(1,1),(1.3,1.5),(2,1.6),(4,1.65))
finishing projects=Cement Consuming Projects/N T to finish*fulfillment ratio
fs([(0,0)-(4,4)],(0.25,0.33),(0.5,0.5),(1,1),(2,2),(4,3))
fsd([(0,0)-(10,2)],(0,0),(1,0.9),(1.37615,0.973684),(2,1),(10,1))
fspeed([(0,0)-(4,2)],(0,0.2),(0.5,0.3),(0.8,0.6),(1,0.8),(1.1,1),(1.2,1.2),(1.4,1.4),(2,1.5),(3,1.5))
fu([(0,0)-(4,1)],(0,0.5),(0.6,0.6),(0.8,0.8),(1,0.95),(2,1),(3,1))
fulfillment ratio=f adequacy(1/demand supply ratio)*effect on demand per project
import ratio=switch to P1*0.6*(STEP(1,0)-STEP(1,3)) + switch to P2*(0.6*(STEP(1,0)-STEP(1,1))+0.3*(STEP(1,1)-STEP(1,5))) + switch to P3*0.2*(STEP(1,0)-STEP(1,9))+switch to P6*0.05*(STEP(1,23)-STEP(1,29))
improving=Capacity to be Improved/average time to improve
N T to finish=12
ND=100
new cap needed=Max(desired capacity-perception about future capacity,0)
Normal demand per project=1
Normal time to finish=30
NP=55*((Accumulated Inflation-1)*switch to show inflation effect+1)
NS=100
percentage of chng in price=f(demand supply ratio)
perception about future capacity=Capacity Online + perception about new plants
perception about new plants=SMOOTH(Capacity to be Improved*(1+raise percentage)+Plants Under Construction, T to chng perception)
Plants Under Construction= INTEG (starting new plants-completing new plants,5)
Price= INTEG (chng in price,40)
production=Capacity Online*capacity utilization
raise in capacity=improving*raise percentage
raise percentage=0.2
shuting down to improve=cap to shut down/Time to SD
speed multiplier=fspeed(DO cap ratio)
starting new plants=desired number of new plants/Time to start new plants
starting projects=Max(("desired # of projects"-Cement Consuming Projects)/time start + finishing projects,0)
supply=production*(1+import ratio)
switch to P1=0

switch to P2=0
switch to P3=0
switch to P4=0
switch to P5=0
switch to P6=0
switch to show inflation effect=0
T to chng perception= 6
T to chng price=0.25
time start=6
Time to SD=6
Time to start new plants=12