Dynamics of Oil Price in the World Market

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Abstract

Oil price in the world market has shown an oscillatory behavior. This paper presents a dynamic hypothesis for such oscillation and a model to test such a hypothesis. As price of oil increases, both oil exporting and oil importing countries react. In oil exporting countries, in the short term, oil revenues increases their financial resources. As financial resources increase, their needs to export oil in the short term drops. They may decrease oil supply. Lower oil supply can increase price of oil further. But in oil importing countries, higher price of oil would decrease oil demand over time by some lag. While in oil importing countries oil demand decreases, oil-exporting countries spend their high oil revenues and develop a government financial structure more dependent on oil. Economic structure of the oil exporting countries also become more dependent on oil and as a result, they need more oil revenues to finance government and economic as a whole. A higher need for oil revenues makes oil-exporting countries to supply more oil. Oil supply increases when oil-importing countries reduces their demand. As a result, oil supply exceeds demand and oil price drops. Lower oil price would decrease the oil revenues of exporting countries and their need for higher revenues would push oil exports higher and causes the price to drop further. Low price of oil creates a reverse chain of effects and will decrease dependency of oil-exporting countries to oil and will cause the demand for oil in oil-importing countries to rise again. Lower dependency on oil revenues lower pressure for exports and rise in demand will push the oil price up again and a new cycle starts.

1. Introduction

Ignoring some singular events such as wars, price of oils show oscillatory behavior over time. Events like oil embargo in 1973, or Iran Iraq Was in 1979, or Kuwait war in 1991 made oil prices to jump sharply. However, after those sharp jumps, oil price returns back and continues oscillation around a relatively stable average price. This paper argues that such oscillation is the result of underlying structure in oil-exporting and oil-importing countries. The next section presents the model structure and the sections after that will analyze the behavior of the model.

2. Model structure

Figure 2 shows major stock and flow variables in the model. There are two stocks representing oil dependent structure and also oil dependent structure under development. Oil dependent structure represents the production capacity created in the public and non public sector by investment of oil revenues. Production capacity in health, education, arm forces, power systems, water systems, transportation infrastructure and facilities, and social welfare are examples of the structure that is developed by investing oil revenues. Oil revenue investment increases structure under development and after construction delay, structure completed will increase oil dependent structure. Depreciation decreases oil dependent structure.

Another stock variable is oil revenues reserve representing cash reserves from oil revenues. This stock increases by oil revenues and decreases by expenditures.

The fourth stock is oil reserve. It is assumed that oil exports deplete oil reserves as an non-renewable resource. In the model we can assume a large initial reserve, so oil resource constraint will not limit oil exports.

“Oil price” and “oil demand base” are the last two stock variables as shown in Figure 2. Oil price changes by a rate of change in price. Demand base is changed by change in demand base. The flow variables are controlled by stock through feedback loops.

Feedback loop 1, shown in Figure 3, is a negative loop that controls oil exports to keep financial resources adequate in oil exporting countries. In loop 1, when oil revenues rises, resources adequacy increases, and oil exports tend to decline. On the other hand, low resource adequacy increases desire to export more oil and raise resource adequacy.

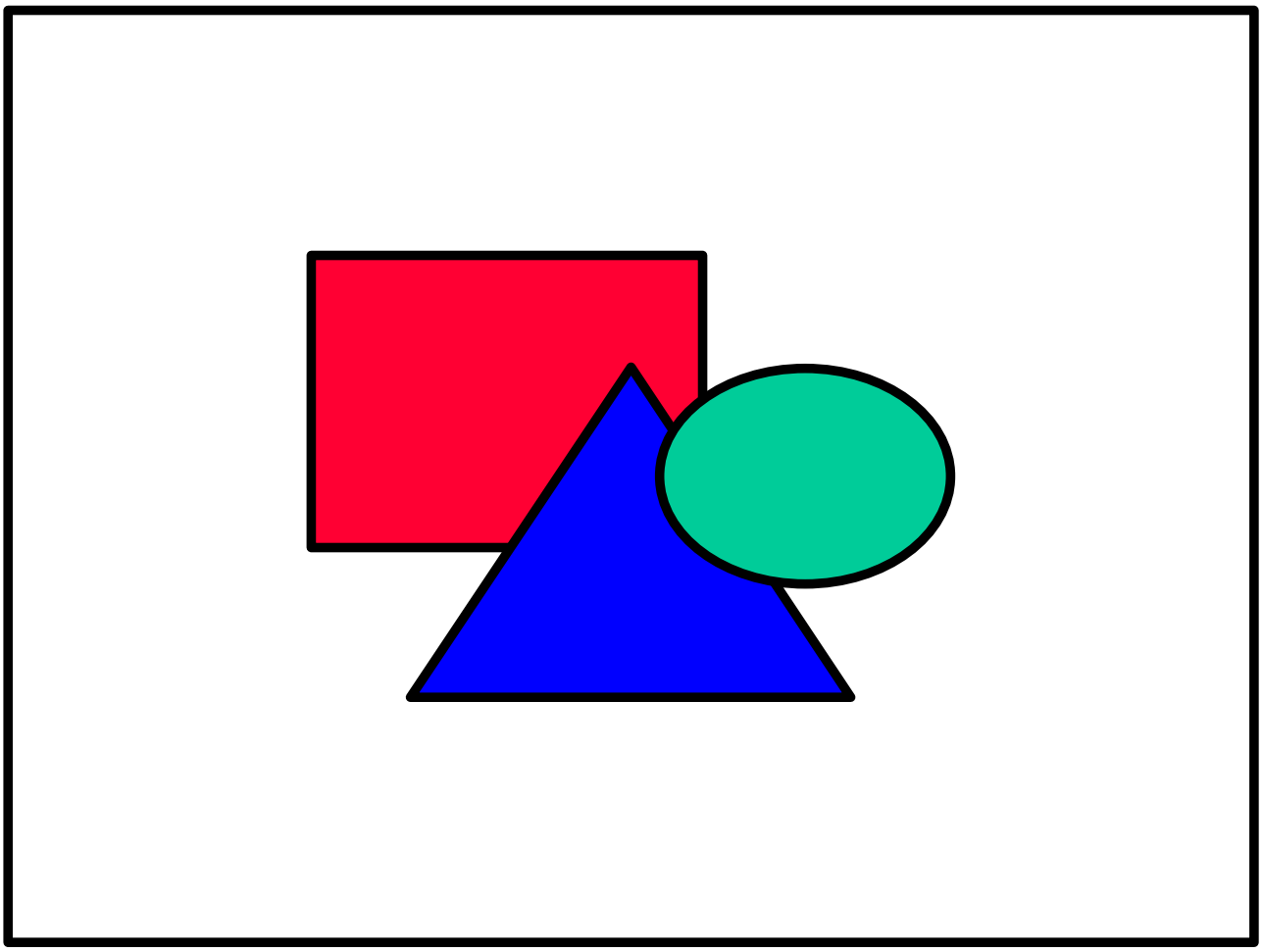

Figure 1: Historical change of oil price

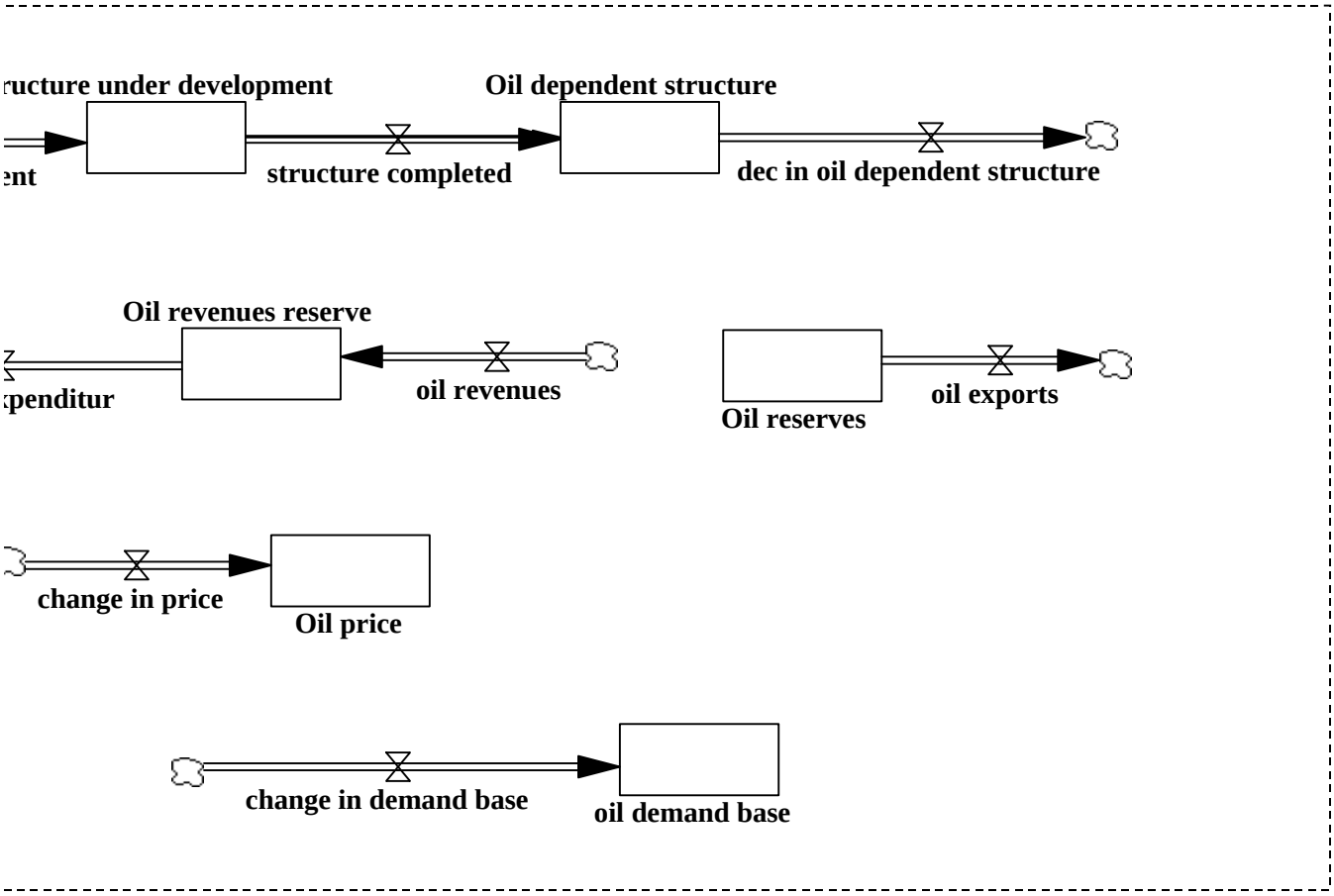

Figure 2: Stock and flow variables in the model.

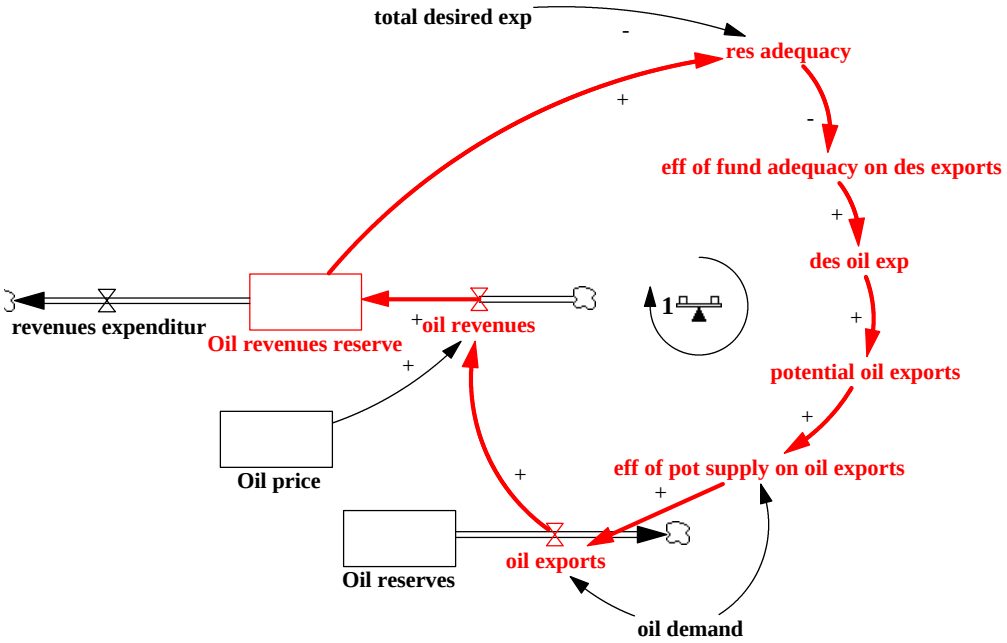

Figure 3: Negative loop controlling oil exports based on financial resources adequacy.

While loop 1 adjusts oil exports to control a normal adequacy of resources, Figure 4 shows two positive loops, loops 2 and 3, that work mostly in the long run to increase oil exports. These two loops work to increase the dependency of oil exporting countries on oil revenues. In loop 2, investment of oil revenues increases oil dependent structure. More oil dependent structure with a growth coefficient, representing natural tendency to grow, would lead to a higher desired investment and more oil dependent structure. In fact as oil dependent structure increases, with a broader base, more investment should be made to keep the growth rate a constant level. In loop 3, when oil dependent structure increases, operating cost of that structure will also rise which together with the desired investment would lead to higher total desired expenditures and lower resource adequacy. Lower resource adequacy leads to higher oil exports and oil revenues. Oil revenues will increase oil revenues reserves and resource adequacy. A higher resource adequacy would increase possibility of investment and lead to a higher oil dependent structure. The process of increasing dependency of oil exporting countries on oil revenues continues with loops 2 and 3 operating (for more discussion on this see, Mashayekhi 1999).

While loops 1, 2, and 3 are major loops that affect desired exports from the oil exporting countries, there other loops that affect price of oil and control the demand in the oil importing countries. Figure 4 shows a positive feedback loop, loop 4, that when price of oil increases, oil revenue rises and revenue reserves increases and raises resource adequacy. High resource adequacy decreases the desire to export oil and as lower oil export increases price of oil to a higher level. This positive loop operates in the short run and causes an oil price increase to lead into more price increase.

Although positive loop 4 makes the price of oil to rise or fall exponentially, there are some negative loops that check the price and do not let it go out of a certain range. Figure 5 shows three strong negative loops controlling oil price. Loop 5 represents the reaction of demand to oil price. When oil price increases, oil consumption reacts by decreasing the demand for oil. Of course reduction of demand is gradual. It takes time to change the technology and readjust processes to reduce demand. Therefore, in loop5, as price of oil increases, oil demand base, representing technological and infrastructure of oil consumption, will drop over time. Lower oil demand base would lead to a lower demand for oil. Lower demand would lead to a lower demand supply ratio and that would decrease price of oil. If the price of oil drops, the loop works in the opposite direction and increases demand to raise the price. In loop 5, the price of oil is anchored to a normal price that allows the demand base for oil to increase at a normal growth rate.

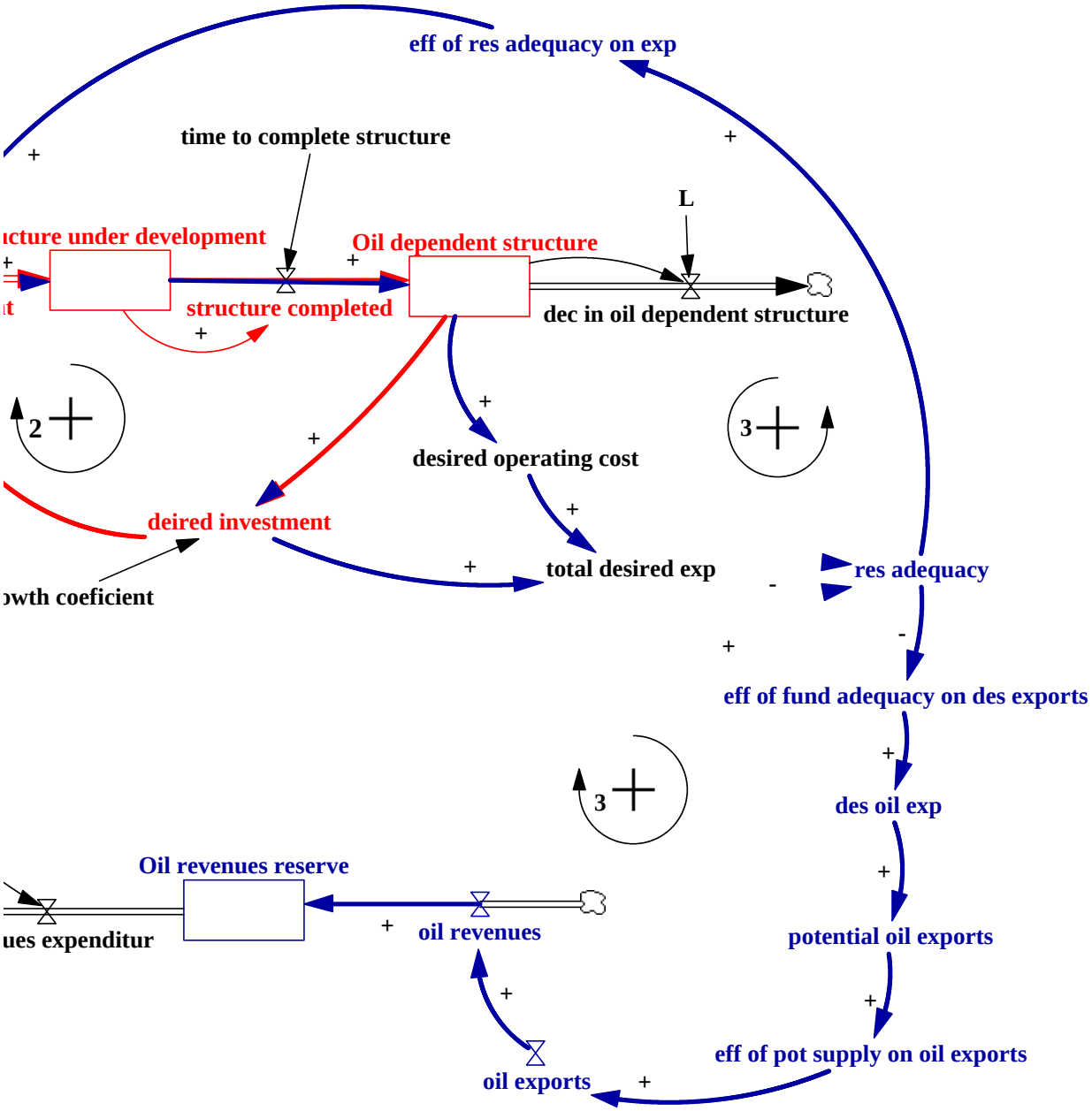

Figure 5: Loops 2 and 3 are two positive loops that increase oil exports as dependency on oil rises.

Loop 6, another negative loop in Figure 5, controls the oil price through its impact on supply. When the oil price rises, desire to export oil increases and leads to a higher oil supply in the market. A higher oil supply would lowers demand-supply ratio and decrease oil price. So oil price affects oil exports in two ways. First through, higher revenues and loop 4 would increase resource adequacy and lower oil exports. On the other hand, through loop 6 it leads to a desire to increase oil exports at a higher price.

Finally, in Figure 5, loop 7 is the third negative loops that control price of oil in relation to alternative energy prices. When oil price increases, the ratio of oil price relative to alternative energy price increases and that decreases the change in oil price. This loop does not let the price of oil to higher than alternative energy price.

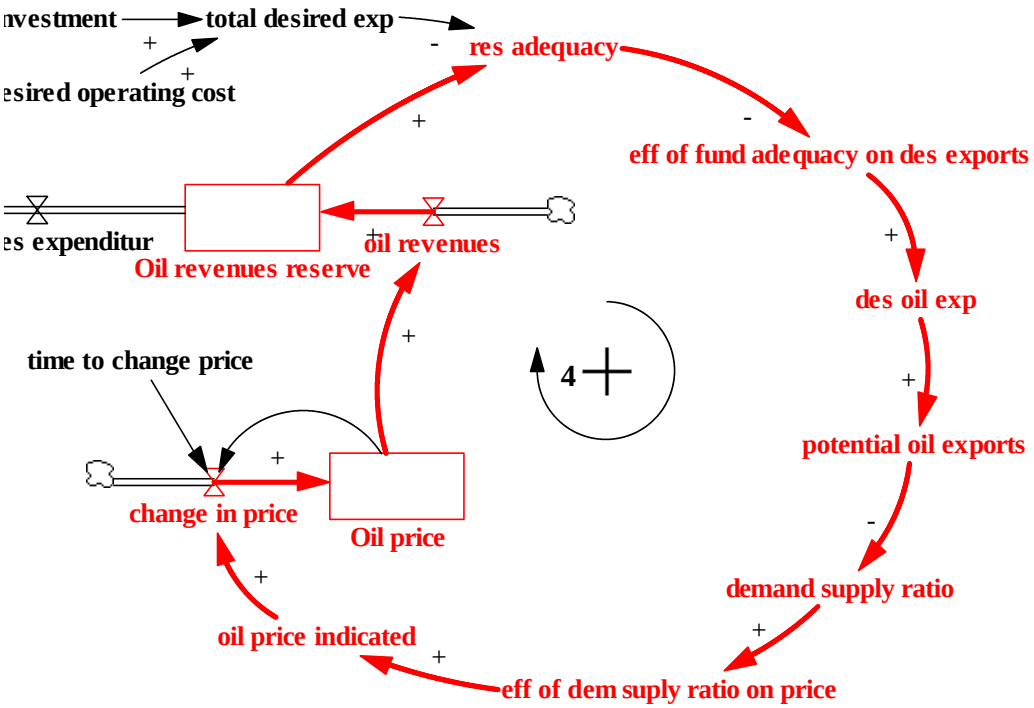

Figure 6: Positive loop that causes the price of oil rise or drops exponentially in the short run

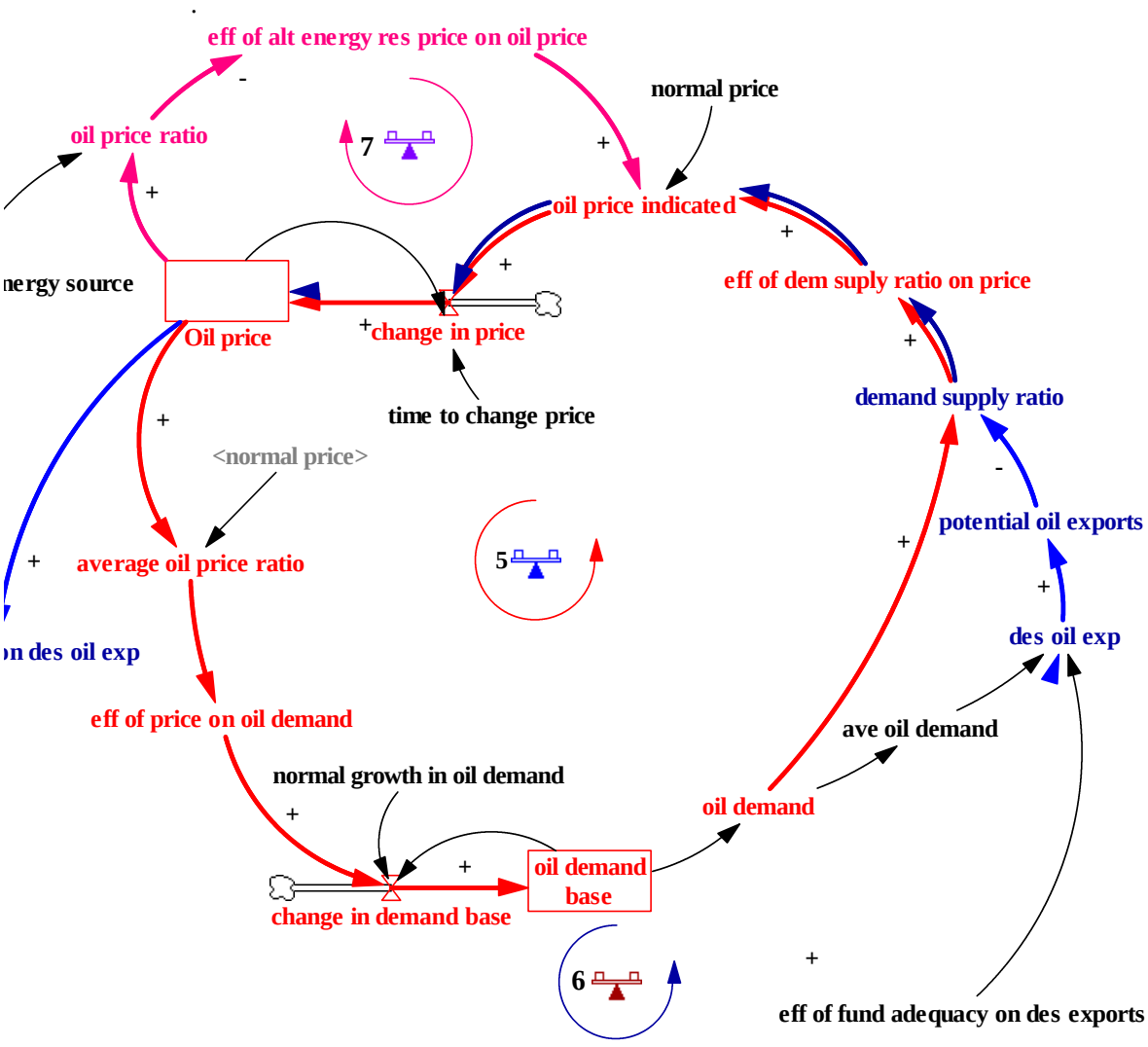

Figure 7: Negative loops controlling the price of oil.

The last major loop is shown in Figure 8, negative loop 8. In loop 8 oil exports is controlled by oil reserves. Oil export depletes oil reserve. When oil reserves decline to a level that can not support oil exports, oil export would decline such that with a zero reserves, no oil can be exported.

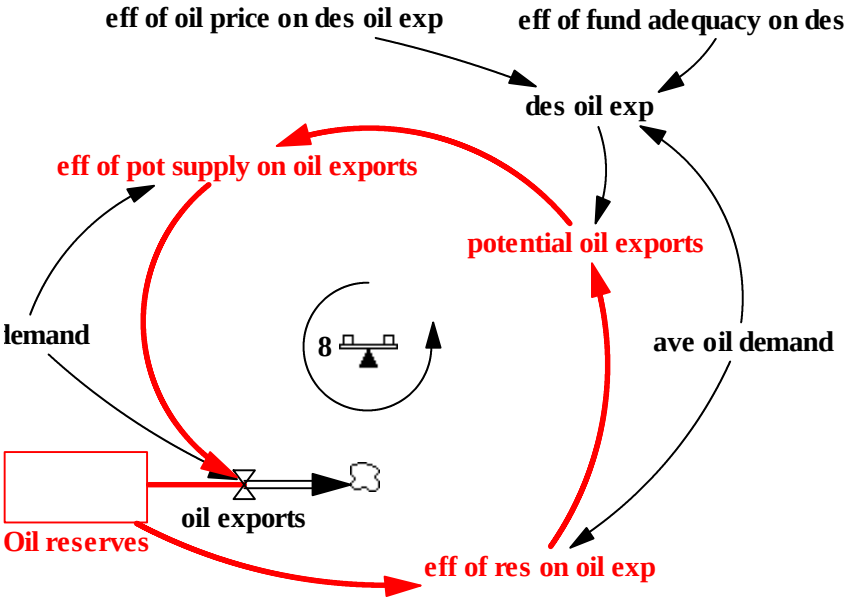

Figure 8: Negative loop that imposes reserve constraints on oil exports.

Model Behavior:

Figures 9 to 13 show the behavior of the model when it is assumed that demand for oil under normal condition in terms of oil price grow exponentially at a normal growth rate. This assumption indicates the normal economic growth process that is going on in oil consuming countries.

As Figure 9 shows, oil price oscillates with a periodicity of about twenty years. The main driver of oil price is supply-demand ratio and its effect on oil. When demand is higher than supply, demand supply ratio is more than one and the price increases. However, if the price of oil should go very high, in this figure it does not go that high, then the effect of alternative energy price declines and limits the growth of oil price. When price of oil remains below the alternative energy price, the effect for alternative energy price remains one, as it is in Figure 9, and does not have any impact on the oil price.

The behavior of demand and supply is shown in Figure 10. Both demand and supply grow with oscillation in their growth rates as oil price oscillates. There are four variables, demand, oil exports, desired oil exports, and supply demand ratio. When demand is more than desired oil exports, demand-supply ratio increases above one. High demand-supply ratio increases oil price and as oil price increases, demands of oil declines. The interesting point is that when oil price starts to go up, desired oil exports does rise, even it falls slightly. This behavior is opposite to what a simple supply curve in economics tells us. The forces beyond this not common supply behavior will be explained in the next graphs. However, while demand starts to come down, supply finally rise and demand supply ratio falls bellow one. When demand is at its lowest value, desired oil exports exceeds demand. As desired oil exports exceeds demand and price of oil falls, demand starts to rise and a new cycle starts.

Figure 11 shows the behavior of oil exports and its main driving forces. Oil exports grow in response to the growth of demand with variable slope or with oscillation in its growth rate. When price of oil goes up, two opposite forces affect exports. Higher price increases the effect of oil price on desired oil exports rises to push up oil exports. On the other hand, when price of oil increases, fund adequacy in oil exporting countries rises and tends to decrease the desired oil exports as revenues from oil is not highly required. However, high fund availability accelerates expansion of oil dependent structure and expenditures. As oil dependent structure expands, more expenditure has to be made and

fund availability drops and the effect of fund availability on oil exports, shown on Figure 11, will rise. But when low fund availability creates pressure to increase oil exports, demand for oil due to high price is not sufficient. Effect of demand on oil exports, shown in Figure 11, restricts oil exports. In fact when fund adequacy is low and effect of fund adequacy on desired oil exports is at its highest value, then both price of oil and demand is low and their impacts keep exports and oil revenues at low level.

Oil demand and its driver are shown in Figure 12. Oil demand also grows with an oscillation. The main force that creates oscillation in demand is oil price. When oil price rises, the effect of oil price drops and forces the demand to fall and vice versa. Of course demand responds with some delay to changes in price as it takes time to change the demand by changing the technology or modifying production and consumption processes.

Expansion of oil dependent structure as oil exports grow is shown in Figure 13. As oil dependent structure grows so does total desired expenditure. Oil revenues also rises by oscillating around total desired expenditure. When oil revenues grows faster than total desired expenditure, resource adequacy rises. Resource adequacy drops when it oil revenues does not grow as fast as total desired expenditure does.

Oil Export Cut

Sometimes production of oil in oil exporting countries falls because of different reasons such as war or embargo or an effort to increase the price of oil in the market. Figure 14 shows the behavior when production of oil in years 41 to 46 is reduced by 40 percent. Oil price goes up more than the base run after year 41. Demand for oil decreases and follows a path below what was in the base run. In fact in year 41 when oil exports drops and oil price jumps up, demand base for oil declines and demand falls bellow its value in the base run. Then after year 46, when oil exports increases oil demand does not get to the same level as in the base run. In addition to lower demand after year 41, there is another point of interest. Reduction of oil exports, gives a pulse to the oscillatory system of oil price and would increase the amplitude of oscillation after year 41. So temporary education in oil exports increases the volatility of the oil market as such a reduction triggers the oscillatory system.

The reduction of oil production can be permanent, Figure 15 shows the behavior of the model when oil export is cut 40 percent of what is desired after year 41. As shown in the figure, oil price oscillates around a value a little more than the average price when the oil exports reduction is only for the period of 41 to 46. Average oil price would not be as much as expected. The main reason for this unexpected or counterintuitive behavior is the feedback between price and demand. Under the new conditions, demand for oil would decrease and does not let the price to rise as much as 40 percent reduction in oil exports implies. Figure 15 shows the amount of oil exports under two reductions scheme. When the exports reduction is permanent, oil demand in year 80 is less than half of what it is under temporary reduction as shown in Figure 15. Figure 16 shows oil revenues for oil exporting countries under three different runs. As shown in Figure 16, oil revenues is higher in the base run after 41 until about year 95 that resource restrictions decrease oil exports to zero by the year of 110. Oil revenues with temporary reduction in oil exports peaks in about year 105 or ten years later than the base run. But in the third run where exports reduction is permanent, then oil reserves last longer and effect of oil reserves, shown in Figure 16, does snot restrict oil exports in the firs 120 years of the simulation.

Conclusion

This paper presented a dynamic hypothesis for oscillation in oil price the world market. The paper argues that an oil price increase would lead to lower demand in one hand and to an increase in oil dependent structure in oil exporting countries on the other hand. Increasing oil dependent structure would require more oil revenues, which would lead to a higher desire for oil exports. Lower demand for oil on one hand, and higher desire to export oil on the other hand, would decrease the price of oil. And a cyclical behavior in world price of oil is generated.

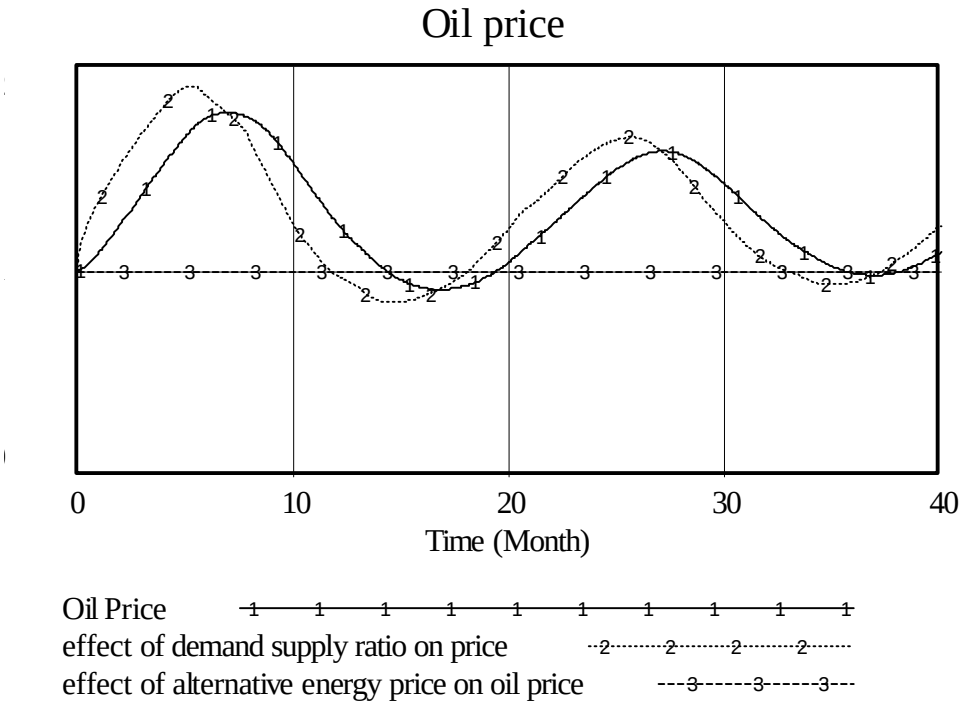

Figure 9: Behavior of price of oil and its drivers.

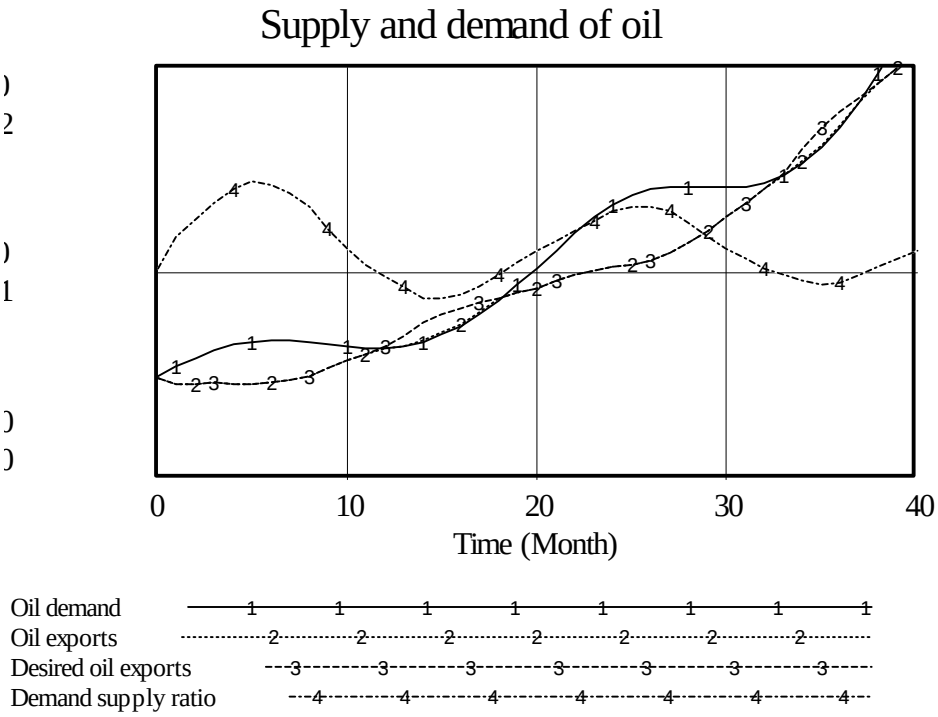

Figure 10: Growth in oil demand and supply.

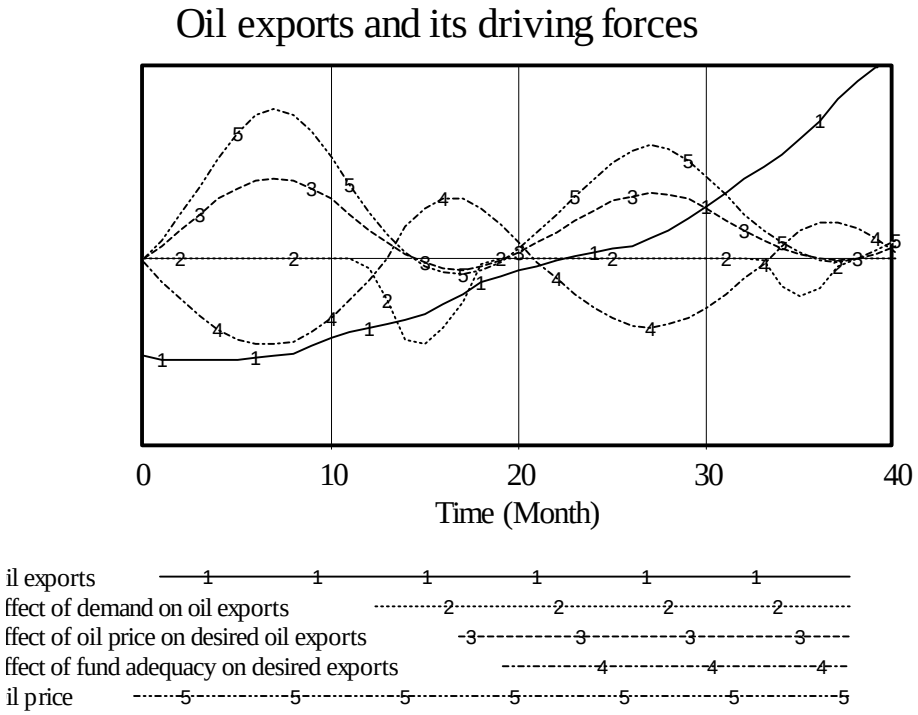

Figure 11: Oil exports from oil exporting countries and determinant forces.

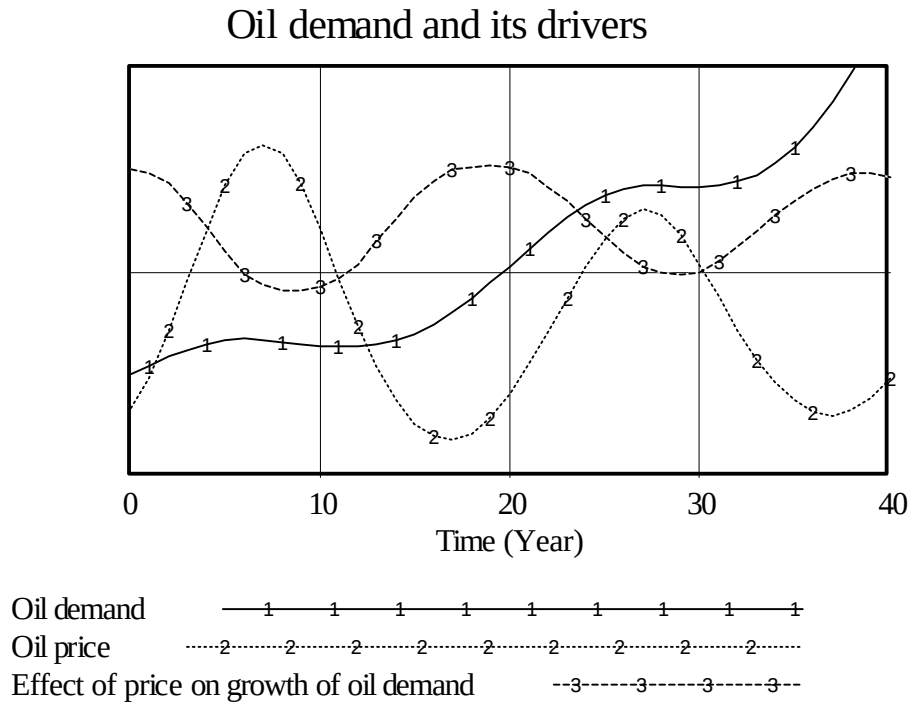

Figure 12: Oil demand and its drivers.

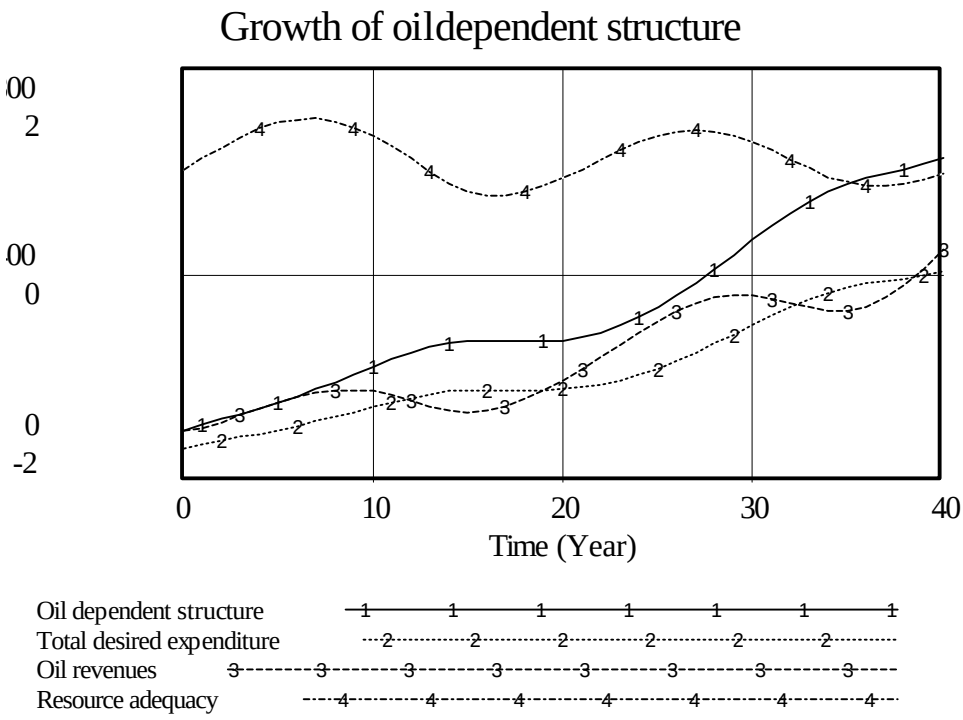

Figure 13: Increasing dependency to oil revenues in oil exporting countries.

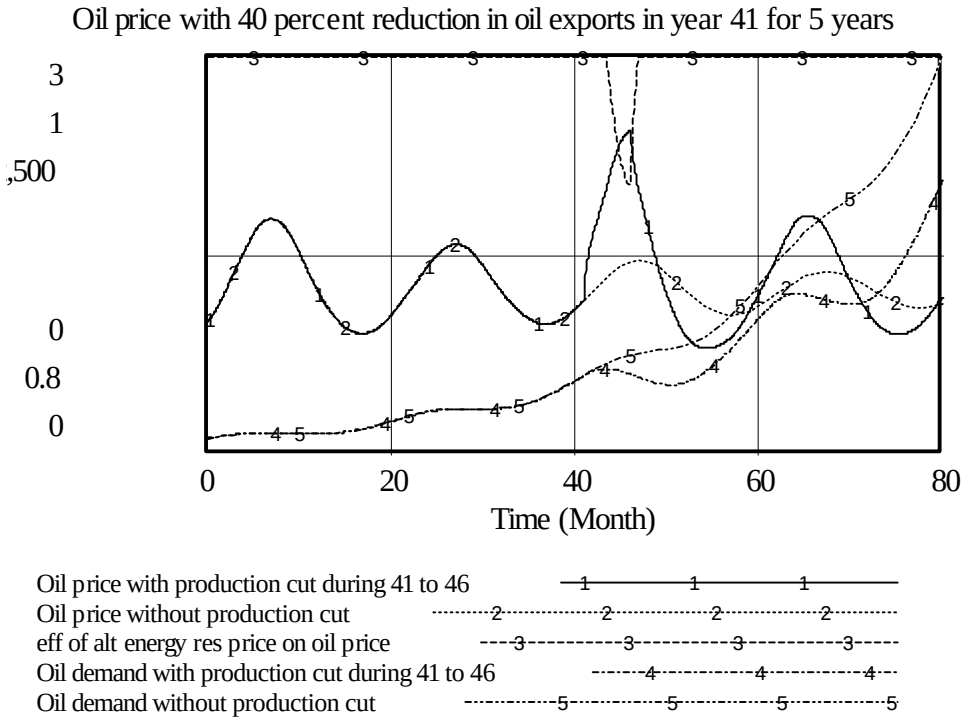

Figure 14: Oil price and demand with 40 percent production cut relative to the base run during years 41 to 46.

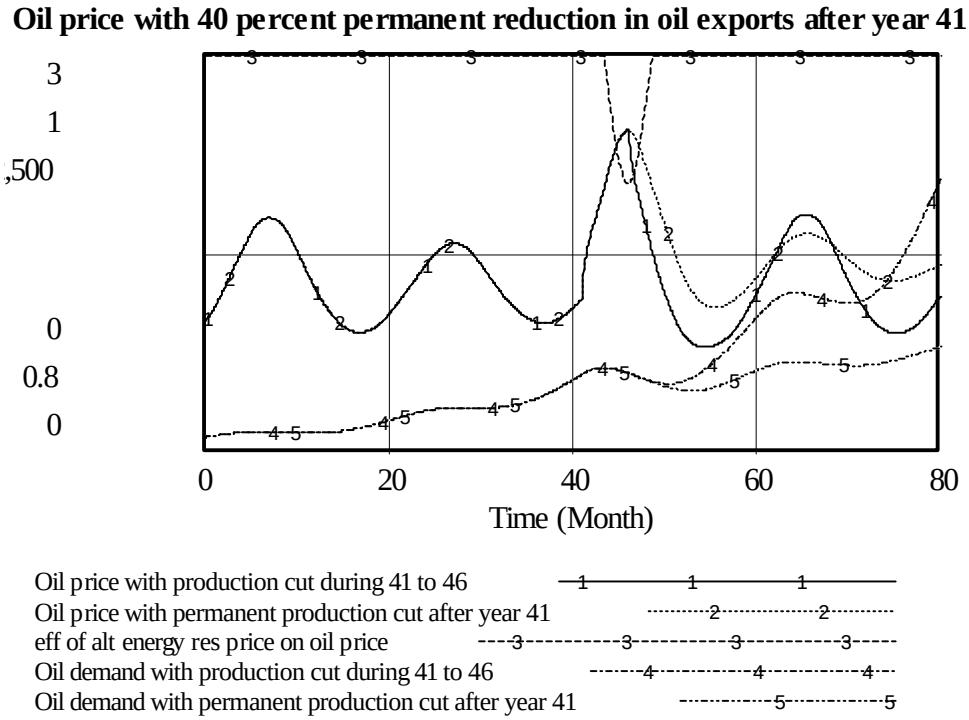

Figure 15: Oil demand and oil price when oil production reduces by 40 percent relative to the base run after year 41.

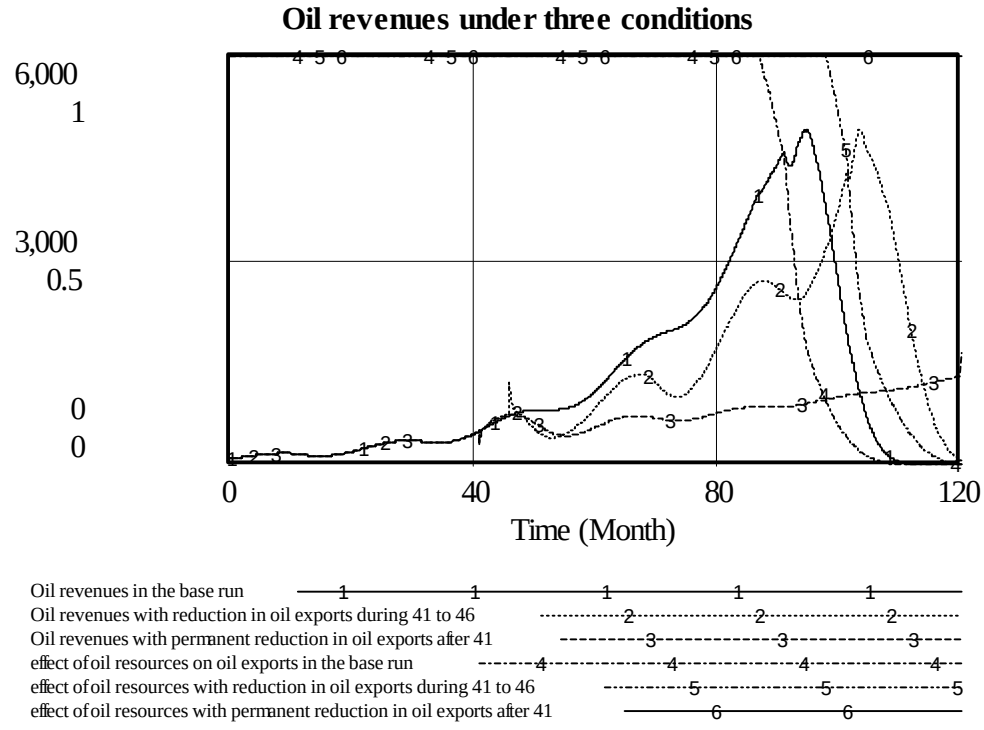

Figure 16: The behavior of oil revenues under three different conditions.

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