The paradox of natural disasters leading to economic growth: The case of the Touhoku earthquake

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B.Sc. í viðskiptafræði

Vor 2011

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Abstract

This thesis looks at the paradox of how natural disasters can lead to economic growth and uses at the Touhoku earthquake that struck in March 2011 in Japan as a case to try to determine the effects it will have on economic growth in Japan. We see from earlier research that countries that suffer frequent natural disasters have a higher GDP growth than countries that do not. Using a model I present we then analyze the investments into human and physical capital and see how Japan's investments into human capital results in long-term growth and how rebuilding physical capital after a disaster hastens adoption of new technology and increases output. In conclusion we find that Japan is likely to experience growth following the earthquake.

Introduction

As we receive news of an earthquake, flood or any natural disaster it is usually followed by a list of the number houses destroyed or damaged, the number of people that have had to evacuate the area and the number of people missing or dead. These numbers quantify for us the damage that this natural disaster has caused to the affected country or area so we are better able to grasp the magnitude of the damage suffered. From these numbers we are likely to assume an immense cost to the affected country and some time for rebuilding before things are back to normal. But what if things don't get back to normal but become better than before the disaster? Although natural disasters cause a great deal of damage disasters are also more likely to promote growth rather than retard it (Skidmore og Toya, 2002; The cost Japan, 2011; Bill Emmott, 2011; Cookson og Pilling 2011; Horwich, 2000). After the earthquake in China in 2008, the Chinese government announced that money that would be put into the rebuilding efforts and the subsequent economic growth would outweigh the economic loss and would result in a total gain in GDP by 0.3% (Bennett, 2008). Similar evidence is found in the aftermath of the Kobe earthquake of 1995 in Japan. The earthquake, that struck in January 1995, resulted in more growth for every quarter, except the first, than in the previous year with a total GDP growth of 1.4% from a 0.6% growth in 1994 (Horwich, 2000). The trend shows that unless there is a fundamental underlying weakness in the system or if there is a radical revolution following the disaster a natural disaster is likely to promote a short-term growth spurt (McRae,2007; Japan and growth, 2011). A study by the World Bank from 2009

even showed that there are other ways in which a natural disaster can positively affect a country, it was shown that soil fertility had increased in the year following a flood leading to more agricultural output (The cost Japan, 2011). The reason why GDP is more likely to grow after a natural disaster has to do with how GDP is measured. When money is sitting in a bank account it has no effect on the GDP, if you take that money from your bank account to buy building supplies though it increases it. The GDP also doesn't take into consideration what you do in your free time, whether you spend it watching TV or clearing rubble it's all the same to the measure of GDP. It has been noted that due to this fault in the way we measure GDP this paradoxical effect is seen (McRae,2007). GDP though is a measure of growth within a country and not a measure of happiness or welfare, it doesn't measure stock either, a growth in GDP after a disaster would show that even with the losses of lives and physical capital the country is producing and functioning at a faster rate than before. A common argument against this creative destruction is known as "the broken window fallacy" by Frederic Bastiat, a French economist. It proposes the scenario where a store window is broken, the window needs to be replaced so a glazier is hired and he is paid 6 francs for his work. It states that the economy is not stimulated by the 6 francs since the shop owner would have spent those 6 francs on something else. What this parable fails to take into account is the possibility of introducing new technology, optimizing planning or the renovation of old or poor quality items or structures. There has even been shown a correlation between long-term growth within a country and the frequency of natural disasters within that country (Skidmore og Toya, 2002). So from this there seems to be a clear connection between natural disasters and an increased growth within a country, following a natural disaster there comes first a short decrease in growth in the aftermath of the disaster followed by a surge in activity that translates in more GDP growth than prior to the disaster.

The purpose of this thesis is to examine the paradox of a natural disaster leading to economic growth using the Touhoku earthquake of 11 March 2011 in Japan as a case and try to predict the economic outcome of it. Japan is a perfect example of a country that is frequently affected by natural disasters and as a result the Japanese have had to adapt to the volatility of the nature of their country. This has the effect of putting Japan in the position of a country waiting for a natural disaster to happen, the Japanese are prepared for it and are expecting it. Studying this might give us a glimpse into what preparedness to a natural disaster can mean to a country. It is unmistakable that if an earthquake like the Touhoku earthquake would have hit Sweden for example that the results would have been much worse as Sweden is almost in the middle of a tectonic plate and as such earthquakes are very rare,

this goes equally for if a poor country would have been hit, the results would have been much worse (Skidmore og Toya, 2007). But in the case of Japan and other countries frequently struck by natural disasters they have adapted to their surroundings and have had to move away from investing as much in physical capital and rely more so on human capital and the development of technology (Skidmore og Toya, 2002). I will introduce a model that shows the relationships and effects that investments into human and physical capital have and with that explain how Japan has become so adaptable and able to grow despite and as a result of frequent disasters. Japan looks more resilient than countries not accustomed to disasters, but Japan has also been seeing a very slow GDP growth for more than a decade now, could it be that this devastating disaster could be the push Japan needed to rise from their economic slump? I will seek to answer that in this thesis and consequently put forward the research question: "Will Japan experience increased growth following the Touhoku earthquake?".

Methodology

In order to assess the economic effects of the Touhoku earthquake on Japan I will mostly base this thesis on historical data, focusing on the aftermath of the Kobe earthquake and data from news sources and from NGOs when possible. All data on the earthquake is very recent when this thesis is written so almost all quantifiable data will have to come from reliable news sources. As has been stated by other researchers into this topic (Tol og Leek, 1998) it is very hard to use mathematical models to describe the outcome of a disaster like this and simple economic models work best as they describe broader tendencies or attractors around which reality revolves. There are also direct and indirect damages to consider, some of which may for example not be noticeable until later, and to the author's knowledge there are as of yet no models that predict the outcome of a disaster based on any factors that can be used quantitatively. I will introduce a new model to show relationships and effects investments into human and physical capital have on output. This model aims to explain how certain investment trends can have multiplicative effects on investment via hastening the development of new technologies and the intergenerational spillover effects of education for example. This model shows us what makes countries that suffer frequent natural disasters able to produce GDP growth despite the destruction they endure. For my conclusion, argumentation has to be relied on which will be based on references to similar disasters and to research that has been done on this topic. This thesis will thus rely mostly on simple

economic models and theories to describe the causal relationships between various factors as well as developing my own model. Using these theories and models and comparing historical data with available current data on the earthquake I will base my arguments for the probable effects of the Touhoku earthquake on short to long-term growth in Japan.

Overview of the Touhoku earthquake

On 11 March 2011 an earthquake struck the north eastern part of Japan, following the earthquake a tsunami struck the north eastern shore of Japan with devastating consequences, the city of Sendai suffered enormous losses in both assets and human lives. The tsunami caused severe structural damage to power plants in the area and damaged the Fukushima Daiichi nuclear power plant causing failures in the cooling systems for several of the reactors. At least three of the reactors are still in a critical state and it has not been possible yet to shut them down, with reports of radiation being released by the reactors. The death-toll has risen above 14.000 with close to 13.000 people still unaccounted for. The destruction seems unfathomable; an estimations has been made though by the World Bank (e.d.) on the cost of the damage caused by the earthquake to reach up to $235 billion, while the Japanese government has estimated it closer to $300 billion (Tabuchi, 2011), numbers that perhaps are still unfathomable. As these events are still unfurling the uncertainty factor is still high with the unstable nuclear reactors and the uncertainty of the psychological effect this disaster has had on Japan and the world. While the reactors in the Fukushima Daiichi power plant remain unstable they are likely to be contained as time goes by. Some radioactive water has leaked out of the plants but there has not been any wide spread radioactivity. In this thesis it must be assumed that the reactors will not explode and that the radioactivity will be contained to the vicinity of the reactors.

Where does the money for rebuilding come from?

When a natural disaster, like a flood or an earthquake, hits a populated area there will be damages, buildings, roads and farmlands are likely to be damaged or destroyed. These properties will have to be replaced if there is supposed to be continued activity in the affected areas and there are four main ways that this rebuilding is funded. The first is by insurance, if

the property that was damaged was insured the money from rebuilding it will come from the insurance company. Secondly, it can come from the private savings of those that were affected by the disaster, relying on self-insurance. Thirdly is in the form of government spending, where the government takes it upon itself to pay for a part of the reconstruction or simply by rebuilding government property. Finally there is foreign aid, where foreign governments or NGOs donate money towards the rebuilding process.

In the case of Japan, damage of this magnitude isn't very likely to be confined to a single country, especially not a country with the third largest economy in the world. Now what will happen when Japan needs between $235-300 billion to rebuild?

Insurance

Natural disasters, unlike car accidents for example, are infrequent and erratic, even in the countries where they are most common. With more frequent accidents like car accidents they are very predictable and as such insurance companies can better estimate their cost. Natural disasters on the other hand are less predictable and affect many people at the same time, meaning that should a flood or an earthquake hit the insurance companies would have to pay out to a large sum all at once. This would mean having more liquidity available or else the companies would have to sell assets to cover the payout. Due to this insurance companies have a much higher premium on natural disaster risks than for example car insurance, charging a 1.43-1.77 premium on natural disaster insurance (Skidmore og Toya, 2002). Looking at the 20 costliest natural disasters since 1965, picture 1, we can see that outside of the United States, where there is the highest percentage of insurance for natural disasters, no other country is insured for even a fifth of their damages, with the Touhoku earthquake being the best insured one outside of the United States.

Picture 1: World's costliest natural disasters since 1965 (The Japanese Ever, 2011)

The amount of insurance that will be paid out in Japan will relatively not be a large sum but still amounts to $14-33 billion (World Bank, e.d), and this money will mostly, approximately $10-20 billion, come from outside of Japan from large reinsurance companies such as Munich Re and Swiss Re (Reinsurance out, 2011). The Japanese insurance companies that will have to pay the remaining amount will likely be forced to sell assets overseas to cover the cost of their payout (Hadfield, 2011). During the 1995 Kobe earthquake only about 3% of the damages were covered by insurance, at that time about 16% of the buildings in Tokyo were covered by insurance even though Tokyo is more prone to natural disasters (Skidmore, 2001). For the Touhoku earthquake with the World Bank's early estimated $235 billion in damages and $33 billion insured we see that this number is even lower compared to the 1995

percentage of 16% down to 14%, it is clear that insurance plays a small part in funding the reconstruction process, since this graph was published the estimated damages have been raised to $300 billion (Tabuchi, 2011) but there is no reason to assume that the percentage of insurance is higher. The economic effects of these insurances will be discussed more in the chapter: “Economic factors”.

Government spending

During times of natural disasters the government will usually devote some money to aid in the reconstruction process. This can be in the form of setting up temporary housing for those that have lost their homes, supplying food and water for those in need, repairing damaged property and infrastructure, providing disaster related loans etc. This can be a very important first response as infrastructure can be disrupted meaning there is no access to food, water or other necessities or that roads and railways are unusable. The reconstruction process would be a later stage of the disaster relief.

The Japanese government has announced a $48.5 billion disaster relief budget; the prime minister of Japan, Naoto Kan said that there might be several other extra budgets to help fund the reconstruction efforts (Japan government budget, 2011). This move by the government is vital in order to build temporary housing and supply basic necessities to the disaster area. Rebuilding of infrastructure should be a second priority to help bring the affected area to a point where they themselves can start rebuilding on their own. The money for the relief package came from pension funds and government projects so the government wouldn’t have to take loans to fund this package as the government’s debt is currently at 200% of the GDP. The subjects of loans and the government’s debt will be discussed more in the “Taxes” chapter.

Foreign aid

Normally when a country is affected by a very destructive natural disaster many countries and NGOs will collectively lend aid to the stricken country. Rescue workers and supplies are sent to aid in the aftermath of the destruction to help return an area to as normal as they can in the shortest amount of time. Like with government aid, foreign aid is usually a part of the

first response action to help until sufficient infrastructures are restored for there to be a semblance of normalcy and the people can take care of themselves. Although important as an early response action foreign aid rarely covers a large amount of the total economic destruction.

Relative to the size of the disaster the financial foreign aid doesn't amount to that much considering that the total damages of the earthquake are estimated up to $300 billion (Tabuchi, 2011) while the foreign financial aid amounts to about $10 million (Herskovitz og Fujioka, 2011). Although this aid only amounts to about 0.000033% of the damages and seems very little it is the relief goods that they bring in the first few days following the disaster that are the most important aspect of this help.

Private savings

From picture 1 we can see that a low percentage of the damage caused by natural disasters is insured, as a result a lot of the money for rebuilding will have to come from the private savings of individuals affected by the disaster. In an article by Mark Skidmore (2001) he shows that there is a strong correlation between household savings rates and the frequency of natural disasters occurring within a country. This suggests that people living in countries that have a higher likelihood of being affected by natural disasters are aware of the risks and as such take appropriate measures by way of self-insuring themselves by keeping larger private savings. As we saw from the "Insurance" chapter the premium on disaster insurance makes them more costly for people than a regular insurances and this might be one way of simply insuring oneself.

With damages of up to $300 billion, insurance will pay out around $33 billion, the government close to $50 billion and with around $10 million in foreign aid, the rest of the money, around $210 billion, will have to come from the savings of Japanese households and companies. There is a correlation between the number of natural disasters in a country and a high marginal propensity to save and Japan is no exception to that with a marginal propensity to save of about 14% (Skidmore, 2001). Furthermore, about 30% of Japanese personal savings have been put aside as a way to finance rebuilding after a disaster (Horwich, 2000). This shows that the Japanese public not only recognizes the threat of a natural disaster but

that they are anticipating it by actively saving especially to rebuild after a disaster. This money is mostly held by financial institutions and a lot of this money is invested overseas by Japanese financial institutions. During the rebuilding phase, that is to come, these Japanese financial institutions will be forced to sell overseas assets in order to come up with enough liquid funds to satisfy the customer demand (Hadfield, 2011), the possible effects of this will be covered in the "Economic factors" chapter.

Construction and rebuilding

Following a natural disaster the first period is spent on stabilizing the situation, bringing aid to those in need and restoring the most basic of infrastructures, transportation, access to food and water, restoring power etc. After which, comes a phase of rebuilding which might be the most critical aspect in restoring the affected area, and even the country as a whole. Factories and places of business must be rebuilt if a country wishes to keep its former level of growth, without rebuilding these a country would not only lose production output but the loss of jobs would increase unemployment. With unemployment increases the government's spending on unemployment benefits, rerouting money that could be used to rebuild. This would also in most cases mean decreased spending from those on unemployment benefits reducing the total spending by that amount added the multiplier effect that would be lost. This should not happen unless there is some fundamental weakness in the economy of that country (McRae, 2007). The trend on the other-hand has been that even if the first few months following a natural disaster there is a decrease in the GDP growth, it does quickly begin to increase even beyond the pre-disaster growth (Skidmore og Toya, 2002). The initial lull can most likely be attributed to the days or weeks during which the disaster is likely to occur over. During that time work shuts down in the affected places and even further reaching, with time though things will quiet down. In many cases this also just means that stock is not destroyed and output lost but rather that output is simply delayed by the impact of the disaster and as soon as work resumes this stock will be put to use (The cost Japan, 2011). Japan's two largest car manufacturers Toyota and Nissan have even reported that output should have reached pre-earthquake levels as soon as December and October respectively (Kim, 2011).

Estimated time for recovery

The estimated time for recovery is a rather hazy term, it has been used to describe the estimated time it will take to replace all destroyed buildings and repair damaged ones. When a building is destroyed in a natural disaster we should not assume that there will be built another building just like the one before it. It is likely that the new structure will be better since even if the building was just like the one before it should be better since ceteris paribus it's simply newer. So when we look at the term "estimated time for recovery" we will have to remember that after this the replaced buildings are not simply as good but better, meaning that at the end of this time we are not only recovering what had been lost but also improving upon it. Another way to view this term is by how long it will take to return production output for the affected area to the pre-disaster levels. This is easier to measure since as was noted before, reconstructed buildings are not the same as they were before while output can be measured in the same units at a pre-disaster level. This is likely to be a much faster process as replaced machinery will be newer and ceteris paribus have more capacity and output than the older machines. Output can also be regained at a faster rate since a combination of physical and human capital is needed but as will be discussed in the "Human capital and physical capital" chapter the loss of physical capital can be supplemented by increasing the human capital.

After the Kobe earthquake of 1995 estimated time for recovery was 10 years, 15 months later Kobe was manufacturing at 98% of its former output, even after 0.2% of the population had died in the earthquake and another 2.5% had relocated outside of the Kobe area. This means that with 97.3% of the original population remaining from earlier they were working at 98% of the former output (Horwich, 2000). Given that the estimated time of recovery now, by the World Bank, is 5 years it is safe to assume that pre-disaster production levels could be reached within a year (Mental earthquakes, 2011). The real time of recovery, in terms of rebuilding, is too arbitrary to be judged in the author's opinion. As was noted before this could be defined as the time it takes to replace all buildings that were destroyed and repair those damaged. But what if the value of the replaced buildings is much greater or lower? If a neighborhood of small and old houses is replaced by several large apartment complexes that house twenty times the amount of people as before, costing thirty times as much as the houses replaced, do we measure it by the number of homes restored? The amount of money the construction cost? Or by the square meters rebuilt on? As the term is too vague in

relations to rebuilding, more emphasis will be placed on studying the recovery of manufacturing output.

Politics

So far studies have shown that in most cases natural disasters will promote growth as opposed to hinder it, there are some examples of where this might occur and is one of the most important factors political stability (Japan and growth, 2011). If a natural disaster is followed by a radical political revolution that might change property rights or something equally disruptive it can lead to a long term negative effect.

The Democratic Party of Japan (DPJ) came into power in 2009, this was the first time since 1955 that the Liberal Democratic Party (LDP) had lost the election. There has been some political unrest since that time and the Prime Minister, Naoto Kan, is the party's second prime minister since 2009. Due to this disaster any political maneuvering could be seen as a very petty thing in view of this crisis (Mental earthquakes, 2011) the Japanese people have pulled together in the aftermath of this disaster to the point where the organized criminal associations, the yakuzas, have been contributing to the disaster relief. So far there has been more unity than there normally is in Japanese politics, politicians from all parties have for example pledged that they will push through a quick and decisive rebuilding program (Koll, 2011). Kan has so far has been seen as handling the aftermath of the earthquake with honesty but where the worries lie is with the possible catastrophe with the nuclear reactors (Emmett, 2011). The nuclear reactors though and any problem associated with them could logically be blamed on the LDP since they were both constructed and maintained during their reign, but Kan has announced that he will refuse to accept pay as a Prime Minister until the threat of a nuclear disaster is over, this could gain him some support for recognizing his responsibility (Japan's Kan over, 2011). But even if there is a shift in power in Japan and the LDP were to take over from the DPJ it is unlikely that they would bring about any change so radical that it would hurt Japan, the greatest threat would be from lesser political maneuverings that could cause greater harm such as refusing to accept the current budget proposal.

Human capital and physical capital

There are two types of destruction, one that affects human capital and one that affects physical capital; it is essentially the difference between the loss of lives and the loss of property. Human capital is best described as education, knowledge and competencies of labor that produces economic value while physical capital is machinery, buildings, factories and the equipment used to create economic value. Physical capital can always be replaced and the damage resulting from its destruction is easily quantifiable, human capital however is much more difficult to replace and the loss of lives is rarely quantified in monetary terms as replacing it does not follow the same rules as with physical capital. It can be quantified though and can be used as a measure of damage suffered by a country although it cannot effectively be "rebuilt", the economic impact of the loss of lives will be demonstrated later in this chapter. Research has shown that in countries where natural disasters are more likely to occur there is more focus on investment into human capital and technology than into physical capital (Skidmore og Toya, 2002), with the increased likelihood of destruction of property through disasters expected return on investment in physical capital declines, this has several effects when it comes to both growth and reconstruction after a disaster. First of all, human capital, although not as noticeable as physical capital, is much more important when it comes to rebuilding. When there is knowledge available, building physical capital is easily done, in the case of recovery after a disaster, rebuilding is faster than building as there is less time needed in planning and designing, and the former investment pattern can simply be copied and updated with new technology to not only replace but improve upon the previous physical capital. Output that is lost due to the destruction of a production site can be allocated to another factory, as factories are not likely to be running at 100% capacity at all times it is possible to keep up the previous output levels by this allocation (The cost Japan, 2011), this is especially true of larger companies with several production sites. Investment into human capital also carries long-term effects, when you invest in human capital you are effectively adding to the educational and knowledge level in a country and increasing it. This will lead to an intergenerational spillover effect from the aggregate stock of human capital, adding a sort of multiplier effect to the investment. Increased human capital will also add to the rate of development of the technology level, of a country leading to another multiplier effect of investment into human capital (Skidmore og Toya, 2002). Investment into physical capital will also have a short to medium-term multiplier effect known as the Horndal effect, which is the gradual mastering of new skills needed (Begg, Fischer og Dornbusch, 2005). As a new

machine or process is introduced workers will with time become more adept at using it, this leads to a continuous increase in productivity, over a period of time, until the new machine or process is mastered. In the original discovery of this effect in a Swedish steelworks this was a 2% annual growth in productivity over 15 years so this effect can have more than just short-term effect. As this applies to new investments in physical capital which are abundant in the aftermath of a natural disaster it can add a multiplier effect to the productivity of the labor in the short to medium-term. To better understand the effects of investment into physical and human capital and what the effects in the short to long-term are on total production the aforementioned effects need to be combined into a single model. Using this model the effects of certain long-term and short-term investment patterns can be more easily understood, this model helps to explain why there is such an increase in GDP growth following a natural disaster and how the long-term investment trend of countries frequently affected by natural disasters help them recuperate from disasters. This model is best described by beginning with a simple production function.

Using a simple production function:

(1) $Y = A*f(K,L)$

Where Y is the output, A is the technical knowledge or level, f is the total of the variable outputs: K, physical capital and L labor. (Begg et al, 2005). The focus will be looking at how investments into human and physical capital will affect the growth of the output, both for the short and the long-term.

We'll begin by adding a function that is the productivity of labor and physical capital, we'll call the productivity of labor pL and for physical capital pK. Instead of using a Cobb-Douglas function for this and assuming that the combined productivity of pK and pL equals 1we skip assumptions and instead focus on how investment affects them. We'll also add a time function since we're dealing with more than one period of time, t0 will indicate this time period while t-1 will indicate the one before. This is mostly used to differentiate between our investment today and the period before since investment in the earlier period will have different effects than the ones in this period. Now we have:

(2) $Y(t0) = A(t0)*f(K*pK(t0), L*pL(t0))$

We then add to this the effects of investments into productivity, productivity of labor increases as investment into human capital increases, the same goes for productivity of physical capital and investment there into, we'll call investment into human capital α. It is not clear to what extent productivity of labor (pL) is increased by investment into human capital (α), so we will have to put an x there to indicate that the amount is unknown. We'll make a special formula to show the productivity of labor (pL) at the current time period. This is the productivity of the former period (t-1) adding the increase brought about by investments into human capital (α) in this period.

(3) $pL(t0)=pL(t-1)+x\alpha(t0)$

We have mentioned before the intergenerational spillover effects that stem from the aggregate human capital from an earlier period and how they will act as a multiplier effect on the increase in human capital for the next period. We will call this intergenerational spillover effect (i) and as it is unknown the quantitative effect of this from the previous period's human capital investment (α(t-1)) we will add an x to it to indicate the unknown number. To account for this effect we put the investment into human capital in this period in the power of 1 added the effect of the intergenerational spillover effect (i) giving us:

(4) $pL(t0)=pL(t-1)+x\alpha(t0)^1+ix\alpha(t-1)$

The formula indicating the productivity of physical capital is like formula (3) only with productivity of physical capital (pK) substituting the pL and investment into physical capital, which we will call β instead of the investment into human capital. So the productivity of physical capital this time period (pK(t0)) is the productivity of the physical capital of the former period (pK(t-1)) adding the increase brought about by investments into physical capital this period.

(5) $pK(t0)=pK(t-1)+x\beta(t0)$

Investment into physical capital (β) doesn't only have a direct effect on the productivity of physical capital (pK) but also has an effect in the form of the Horndal effect that has been mentioned earlier. To account for the Horndal effect we will have to add it to formula (5). We will call the Horndal effect h in the formula, it has an unknown amount of added positive

effect, which we'll indicate with an x, in relations to the amount of physical capital investments of the previous period (β(t-1)). By adding the Horndal effect into formula (5) it seems to have a multiplier effect on the productivity of capital (pK) between time periods but only in the sense that as a machine becomes more productive as the labor masters them there is no demand for a machine that is only marginally better so the productivity of the new capital has to take into account the accumulated Horndal effect on the previous machine. The Horndal effect will not accumulate forever since at a point in time a machine will have been mastered, the Horndal effect thus only accumulates on new machines. So now formula (5) changes into:

(6) $pK(t0)=pK(t-1)+x\beta(t0)+xh\beta(t-1)$

Referring to formula (2) again to show how investment into human capital increases the rate of technological advancement we need to find the A(t0). To find that we put A(t-1) in the power of 1 adding then the increase from investment into human capital from the previous period, since we do not know how much effect it has we will have to put x there for the unknown amount of effect it has. To find A(t0) we have:

(7) $A(t0) = A(t-1)^1+x\alpha(t-1)$

Putting all of the fully formed formulas together we have a model that demonstrates the effect investment into human and physical capital has on the output of a country and the multiplier effects with it. This model also allows for it to be used between more than one time periods. Combining formulas (2), (4), (6) and (7) we get the model:

(8)

$$Y(t0) = A(t0)*f(K*pK(t0), L*pL(t0))$$

$$pL(t0)=pL(t-1)+x\alpha(t0)^1+ix\alpha(t-1)$$
$$pK(t0)=pK(t-1)+x\beta(t0)+xh\beta(t-1)$$
$$A(t0) = A(t-1)^1+x\alpha(t-1)$$

This formula gives a very visual idea of how the added effects a steady and long-term investment into human capital will bring, in terms of compounded growth over a longer period of time, and how the trend of disaster prone countries to invest into human capital over physical capital can result in over-all increase in growth. The effects of investment into physical capital should though not be discounted as a measure to increase growth. The two ways in which technological advancement comes about is first by invention, where the human capital is important and then by innovation, where the new invention is implemented into the production process, this is where the destruction of natural disasters again acts as an expediter (Begg et al, 2005). But this model also shows us that by replacing physical capital there will be a multiplier effect, with the Horndal effect on its productivity in the short to medium-term meaning that as soon as manufacturing sites and production plants have been rebuilt their output will increase even more than the added production capacity suggests.

So with a long-term high level of investment into human capital, for the intergenerational spillover and increased speed of technological advancements, and a regular renewal of physical capital, to keep the Horndal effect continuous, a country should be able to keep growth very high. With frequent natural disasters forcing renovation of physical capital and investments moving towards human capital, this might be what causes sustainable growth over the long-term in countries frequently ravaged by natural disasters. This also shows us how valuable human capital is in terms of economic growth and how loss of lives can have severe the economic loss of human lives.

Japan is no different from other countries prone to disaster, it is renowned for its innovative technology and rapid technical advances. According to numbers collected from the OECD in 2008, 43% of Japanese people finish a tertiary degree, making them the third highest in the world in tertiary degrees per capita (OECD, 2010). This demonstrates the high level of human capital investment in Japan. As money is poured into reconstruction following the earthquake new factories, equipment and procedures will substitute older versions. These versions ceteris paribus will be more productive than the older models they substitute, adding to that the Horndal effect should be felt as well in the following years leading to the heretofore mentioned multiplier effect of implementing new technology. As rebuilding slows down over the following years and investment patterns normalize to the non-disaster levels the physical capital investments will give way to the human capital investments. This investment into physical capital will be the short to medium-term growth that will follow the

earthquake while the long-term trend of high human capital investments will keep the long-term growth at a faster pace.

During the earliest stages of rebuilding there will be some shortages of physical capital such as factories and production sites, during this time the combination of physical capital and human capital can be changed to give a similar level of output. When there is a shortage of physical capital more workers can be added to substitute it. Factories are not working at 100% capacity so even with loss of factories others can pick up the slack by working at full capacity to meet demands. Disaster prone countries focus more on investing in technology and human capital so loss of physical capital is not as devastating as it may seem. The loss of human lives is not factored in as economic damages but it can be, but this loss cannot be replaced like physical capital. The economic value of an average life of an American in 2000 was about $2 million (Horwich, 2000), adding inflation to that value to represent the value in 2011 we get just under $2.6 million, we'll assume that this is also the same in Japan as these are both countries with high education and powerful economies. To date there have been confirmed 14.000 deaths from the Touhoku earthquake with another 13.000 people missing, if we calculated the absolutely minimum economic loss assuming only 14.000 people were killed this is a loss of approximately $36.4 billion making the cost of the disaster actually more than 13% higher than expected. This number is likely to be more than 50-70% higher in reality from the number of missing people found alive over the last weeks, meaning there could be an economic loss of $60 billion unaccounted for in estimates.

Technology

During reconstruction the old buildings aren't necessarily built, reorganization of areas may occur and new technology is adapted making for more efficient use of space and machinery and more resistant buildings. Older buildings are more likely to be destroyed than new ones ceteris paribus, during the 1995 Kobe earthquake buildings built after 1981, when a new building code was legislated, suffered mostly only minor damage (Horwich, 2000). In that case buildings of inferior quality were destroyed and replaced with better ones that were less likely to suffer damage should another earthquake hit. This is a good example of how technology advancements are implemented into an area that has been affected by natural disasters, with the destruction of physical capital comes the need for rebuilding, leaving an

incentive to introduce new technology. According to Begg et al. (2005) there two stages of technology advances which is first the invention, the discovery of new knowledge and then of innovation, which is when the invention is incorporated into the system. Large machinery for manufacturing and production can be very expensive and depreciated over up to 20 or more years, replacing a machine like that while it is still in operating condition can have an opportunity cost much higher than the gain from the increased productivity. However when forced to replace the machinery the cost difference between the former model, which might now be over a decade old, and a new one, the manufacturing capabilities of the new model are likely to make it more attractive. As was pointed out in the previous chapter this also hastens the technology level growth of a country.

Japan will now have to rebuild $300 billion of property damaged or destroyed, new and better houses will be built, among those many that are more resistant to earthquakes, new production sites and manufacturing plants will have to be built which should translate into newer and more productive facilities. Using formula (4) from the previous chapter we see that this new equipment should translate into more productivity from physical capital with a short to medium-term Horndal effect that increases labor's productivity as well. The output of Japan should see an increase from this effect as well as from the increased spending that will be discussed in the "Effects on GDP" chapter later on.

Economic factors

Following a destructive event such as a natural disaster it is unavoidable that it will have implications on economic factors such as inflation, currency rates and even have international effects. As demand grows and supply is retarded, due to the destruction of the means of production, inflation is a likely result. Currency rates can increase as well with foreign investors unloading their supply of it causing trouble for export-oriented countries. The international effects could be severe as well if the affected country is a big player on the global scale. Michael Lewis (1989) describes this scenario with the help of a model developed by Kaoru Oda but on a much larger scale in his article "How a Tokyo earthquake would devastate Wall Street and the world economy". In his article he describes a scenario where Tokyo is hit by a massive earthquake and $1 trillion in US assets and bonds is

liquidated by the Japanese resulting in interest rates in the US going up by 5%. But how close to reality is that?

The Japanese stock market fell by about 16% in the week following the earthquake; the Japanese government injected $37 billion into the financial markets in order to stabilize the markets (Bank of calm, 2011). Three months after the earthquake the Nikkei 225 had stabilized and was about 5.5% lower than the day before the earthquake. Earliest reaction to the earthquake was panic and although of course there will be an economic downturn in Japan in the short-term this will likely subside soon and estimates say growth should return by year's end (Kihara og Ishiguro, 2011; White, 2011; Instant view quake, 2011). This growth will then most likely carry on for some years to come, meaning that any investment in Japan right now should be viewed as having turned into long-term investments. In the aftermath of the Kobe earthquake there was a drop in share prices in the first quarter but by the end of the year it had reached its former heights (Horwich, 2000). What will happen in the next few months is that rebuilding will begin which will have tremendous effects on economic factors. In earlier chapters we have discussed how reaching economic stability is best achieved by attaining a stable GDP growth, this will be Japan's challenge.

Inflation

Right now there is a shortage in Japan, supply is not meeting customer demand and manufacturing sites and factories are already increasing their output (Kihara og Ishiguro, 2011; Tomisawa og Slodkowski, 2011). This could lead to inflation if production doesn't keep up with demand. Nevertheless, the increased spending that will follow the $300 billion or so reconstruction over the next few years is likely to lead to an inflation, ending the more than 15 year deflation Japan has been experiencing (Koll, 2011). During the rebuilding phase following the Kobe earthquake there was also a shortage in supply but the stability in prices that remained has been attributed to the availability of substitute products which worked as a counter-weight (Horwich, 2000). Japan has been experiencing a deflation since the aftermath of the Kobe earthquake, this can be attributed to the radical reform that was made in the labor market where life-time contracts were broken among other things, this sort of radical political change is something we discussed in the "Politics" chapter as being able to affect growth. Right now the purchasing power parity in Japan is in line with other countries and the Big

Mac and Starbucks indexes show the same (Koll, 2011). So with Japan having corrected the high domestic price level premium, bringing them in line with global levels, as well as seeing an added spending due to reconstruction and the multiplier effects it will have with the added income we should see a healthy level of inflation in Japan. The Bank of Japan has raised its expectation of consumer price inflation from 0.3% to 0.7% for this fiscal year ending in March 2012 (Kihara og Ishiguro, 2011).

The yen

Japan is an export nation and hence has to keep the yen under a certain exchange rate against other currencies to make them an attractive and a competitive choice, if the yen were to appreciate too much buying from Japan would be too expensive. For this reason, if Japan is to rebuild its economy it is important to not allow the yen to appreciate too much as they are too dependent on their export to disregard it. Immediately following the news of the Touhoku earthquake foreign investors started selling off Japanese yen resulting in it depreciating, as they realized that Japanese insurers would have to repatriate billions of dollars' worth of investment abroad yen was bought back, stabilizing the price (Hadfield, 2011). Shortly after the earthquake the yen reached its highest value to the dollar since after World War II, the G-7 acted together with the Japanese government in an intervention to stabilize the yen as well resulting in a depreciation of it (Appelbaum, 2011). This shows that investors have faith in Japan's ability to rebuild itself and become a stronger force than before. The Japanese finance minister, Yoshihiko Noda, has announced that they would watch currency markets closely for movements but has not mentioned any more interventions (Kihara og Kaiimoto, 2011). It can be assumed then that Japan has not so far seen a reason for any such action and that the yen is at a comfortable level for them, the largest insurers in Japan are even anticipating depreciation in the yen and are planning to raise their holdings in foreign bonds by hundreds of millions of dollars each (Sano, 2011). So with the yen being closely monitored by the government and bet against by the largest insures in Japan it is safe to assume it will either depreciate or remain stable leaving the export focused nation in a favorable position for the rebuilding period.

Taxes

Japan's national debt today stands at about 200% of its GDP, now with Japan spending $50 billion on a disaster relief package and possibly introducing more later, discussion has been raised about Japan increasing their taxes in order to fund their rebuilding efforts. It has been suggested that Japan either raise its sales tax, which is only 5%, or that they raise their income tax ,the OECD even goes so far as to suggest quadrupling the sales tax from 5% to 20% (White, 2011; Tabuchi, 2011). This could be disastrous for the reconstruction efforts and to achieving economic stability in Japan. To begin with, right now in the aftermath of the earthquake and the tsunami it is only natural to assume consumption will decrease due to stores being closed or destroyed in the disaster area and reduced income from the disruption in work. This amounted to a total of 7.8% decrease in retail sales in March 2011, the largest fall in retail sales since 1998 when it dropped by 14.3% when the government increased the sales tax from 3% to 5% (Kaneko, 2011). This was a 66% increase in sales tax; the effect a 300% increase would have could be devastating to the economy and cause a decreased spending when the government wants to see increased spending. Looking at a model of consumption during and not during a natural disaster by Mark Skidmore (2001) we also see a fundamental flaw in proposing an increase of the consumption tax. The formula is:

(9) $C2 = (Y1-C1)(1+r)+Y2.$

In this formula Y represents income, C is consumption and r is interests, consumption and income are divided into period 1 which is not during a natural disaster and period 2 which is during a disaster phase. This model shows that to be able to afford consumption during a disaster phase savings with interest plus income during the disaster phase must be equal or greater than C2. Following a natural disaster those that are the worst off are those whose homes and cities were destroyed and thus place of employment like most of the citizens of Sendai in Japan, for these people there is no Y2 during rebuilding. They will be forced to rely solely on their savings to cover their consumption and by increasing sales tax the purchasing power of their savings has been reduced by that factor. If Japan would do as the OECD suggests and increase the sales tax from 5% to 20% these people would essentially see 15% of their savings eaten up by the sales tax. This would mean that these people might not have enough money to pay for the rebuilding of their homes and replacement of their possessions and would have to rely more on the government's help. Taking money from those in need in

order to pay for disaster relief for those in need results in no gain for the government and is illogical. It has been shown that a decrease in income tax and an increased consumption tax will significantly boost economic activities in the long run as it is encourages work (Kitao, 2011). This is a change that even in the long-run seems to be extremely hard for Japan to make since during the transitional period it will negatively affect retired persons, and seeing as how Japan has one of the oldest populations in the world this could be disastrous to their welfare. Making this sort of change though over a short period of time and during the aftermath of a natural disaster could hamper growth by reducing spending, leading to a slow recovery and reducing any inflation the reconstruction could bring about leaving Japan in a continuing deflation. An increase in sales tax would be bad for the reconstruction efforts and especially for those that have suffered most, anything along the lines of the increase the OECD suggests would be devastating. On the other hand, if there is an increase in the income tax, those that are the worst off will not be affected by it, even if there is general public support for it, it will mean people will earn less money and spend less, if the Laffer curve has taught us anything it's that higher taxes don't necessarily mean more revenue for the government. One option might simply be to finance the relief packages by borrowing from abroad. Even though the government owes 200% of the Japanese GDP when inter-governmental debts have been paid it comes down to 120% of GDP and even then most of it is financed domestically so it should be easy for them to borrow from abroad (Mental earthquakes, 2011). This would ensure that domestic spending would not decline due to higher taxes and would increase the money in circulation adding a multiplier effect to it increasing GDP growth further.

International effects

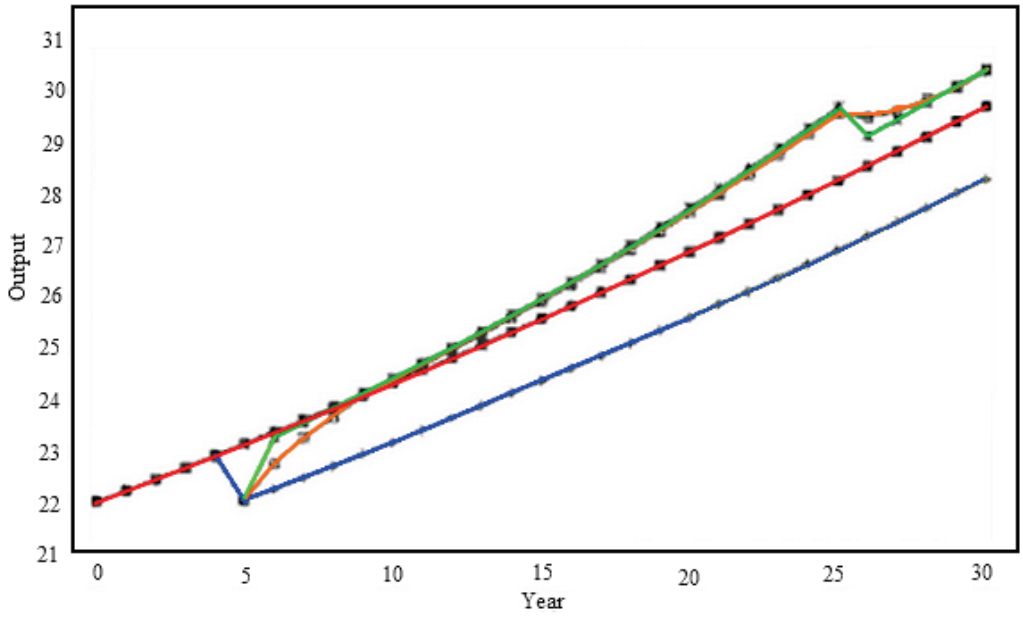
In a model developed by Kaoru Oda an earthquake in Tokyo measuring an 8 on the Richter scale was predicted to cause devastating economic damages for the USA and the West resulting in 5% inflation in the US as Japan sold off $1 trillion's worth of bonds and shares in the US (Lewis, 1989). The reality was only a third of the damage; the model also assumed that all lines of communication would be broken and that the Japanese stock exchange would be paralyzed. What happened instead was international co-operation with the G-7 helping to stabilize the yen and Japan being much better prepared for this. We have covered some of the international effects so far, the payout from foreign reinsurance companies and the possible

manufacturing disruption for companies relying on Japanese parts in their production, but what is the extent of these effects? To begin with, the most easily quantifiable effect is from the payout of foreign reinsurance companies. Hannover Re has reported expected earnings to be €150 million less than they had expected for this year and Munich Re has reported that they will not be seeing a €2.4 billion profit as they had predicted and has refused to put an estimate on their profit this year (Gould, 2011a; Gould, 2011b). This is not all a result of the Touhoku earthquake as there have also been floods in Australia and powerful earthquakes in New Zealand as well, all of this combined has had a lot of impact on the reinsurance companies. By mid-May 2011 share prices of Hannover Re, Swiss Re and Munich Re had fallen by about 0-8,5% since the beginning of the year with all of these disasters taking their toll. Overseas production that relies on Japanese parts will also feel the effects of the earthquake, there will at the least be some delay in delivery of parts from Japan as well as probably some reduced supply. Japan manufactures about 40% of all light weight memory chips, used for digital music players, smart phones and tablet computers (Lohr, 2011). With these objects becoming more and more part of people's normal lives this could affect sales for companies relying on these parts from Japan, this goes as well for auto parts, complex industrial machinery and other electronic goods. There are likely to be other effects not perhaps as big as those that affect the reinsurance sector and auto and electronics industries. This could include the fishing of tuna and other seafood that is exported to Japan; it has already resulted in shut down the whaling industry in Iceland for the summer of 2011 (Hvalveiðum tíma, 2011).

Effects on GDP

So far various sources have shown that natural disasters have an increased growth effect on a country's GDP (Skidmore og Toya, 2002; The cost Japan, 2011; Bill Emmott, 2011; Cookson og Pilling 2011; Horwich, 2000). This has to some extent to do with how GDP is measured, that is, it is not a measurement of accumulated wealth or stock but the production within a country. Growth in GDP then means that this year there was more production than in the year before. After a disaster hits a country resulting in property either damaged or lost, as long as there is money available this should lead to rebuilding of that lost property. As long as the rebuilding results in more expenditure than the loss of manufacturing and production this will lead to a growth in GDP. At first glance this simply looks like a glitch that will even

itself out in a short while and after the rebuilding it will become apparent the real damage of the disaster. On the contrary, this reconstruction phase will usually substitute for the production loss in the short-term and increase the growth of the GDP. As the growth is increased there will be a multiplier effect of the increased circulation of money that again increases spending and earning. When manufacturing plants and production sites have been rebuilt they will not only operate as before but with new machinery they will operate more efficiently and as was demonstrated by formula (4) there will be an added productivity rate from the labor as well over the short to medium-term due to the Horndal effect adding a continuous growth over a longer period of time than simply the rebuilding phase. So during the rebuilding and following it there will be an increased activity leading to a faster growth in GDP, than before the disaster. In a recolor of a graph made by Tol and Leek (1998) lines have been plotted to demonstrate output during and following a natural disaster.



Picture 2: Output after natural disaster (Tol og Leek, 1998)

In picture 2 the red line indicates output without disaster, the blue line indicates output with a disaster and with no insurance, the green line is output with disaster but immediate replacement by insurance while the orange one is with partly delayed insurance.

The term “insurance” here is not only that of commercial insurance but can be private savings used as self-insurance, meaning that as long as destroyed property can be replaced it should be accounted for as insured. This means that as long as there is available capital to

replace means of output this will lead to an increased output, even with the short-term loss in output, and thus an increase in GDP.

Estimations by the World Bank sees a growth in Japan's GDP as early as late 2011 which could last for five years, which is their estimated time for reconstruction in Japan (World Bank, e.d). The OECD is forecasting a 0.8% GDP growth for 2011, from an earlier estimate of 1.7% and then a 2.3% growth in 2012 up from a 1.3% growth estimate, resulting in a total of 0.1% GDP growth gain over the first two years (White, 2011). The Bank of Japan is estimating a 0.6% growth down from their earlier estimate of 1.6% for 2011 with 2.9% up from 2% for 2012 (Instant view quake, 2011). The negative effects of natural disasters are typically short-term effects, after which rebuilding will begin. During that time money is poured into reconstruction creating new jobs, boosting activity and increasing income (Emmott, 2011). Another shimmer of light in an otherwise bleak situation is that the agricultural output of an area that has been hit by a flood is typically increased the following year (The cost Japan, 2011). Although production may have been disrupted by the earthquake it is likely that output will return to its earlier levels within too long, factories rarely produce at maximum capacity so by fully utilizing factories to make up for those that have been destroyed and by increasing labor usage, output can be raised (The cost Japan, 2011). It is also important to realize that where the earthquake struck matters, the area most affected by the earthquake and tsunami is not an area that has a very sizable portion of Japan's GDP accounting for only about 6-7% of it (Japan disaster crisis, 2011; The cost Japan, 2011). The injection of foreign aid also accounts for some increase in GDP with its multiplier effect. Probably the worst threat to GDP growth in Japan right now is power shortages; with the failure at the Daiichi nuclear power plant other nuclear power plants have been shut down reducing the supply of electricity. But Japan's biggest business lobby, Nippon Keidanren, has instructed its members and associations to present a plan of how they will cut down power use by 25% by summer. Tepco (Tokyo Electric Power Company) has announced that they will be able to supply 52.000 MW of power when the peak use will be at 60.000 MW over the summer. But with the estimated power cutbacks needing perhaps only to be at 10-15% Nippon Keidanren is firm on their 25% cutback, so far companies accounting for 40% of the peak power usage have submitted their energy savings plans (Maeda, 2011). Other creative measures might be taken as well to increase the supply of electric power, Chubu Electric Power for example is considering firing up some of its fossil fuel burning plants that are no longer in use (Tomisawa, 2011). Japan is known for innovation and clever solutions to

problems, such as JIT production, there is no reason to believe they will be unable to solve this problem.

The more prepared one is for a disaster the more adaptable they are likely to be and better off, Japan suffers disasters regularly and is no stranger to earthquakes or tsunamis. There is a trend of earthquakes in Japan and they expect them in Tokyo about every 70 years, there has been a big earthquake in: 1633, 1703, 1782, 1853 and 1923. The author lived himself in Japan autumn 2005 till summer 2006, during which time he was frequently told that there was a large earthquake scheduled that was already late so it might strike any minute now. This preparedness is also noted in Japan's high propensity to save and that 30% or so of private savings is meant for rebuilding after a disaster. So in summation, Japan's GDP will most likely slowdown in the first one or two quarters but then pick up and pass its original growth as early as late 2011 and keep growing at an accelerated rate for some years.

Short-term and long-term effects

The short term effects of disasters have been mentioned in earlier chapters and what causes them, but to reiterate; when a disaster strikes it will cause disruptions in production and slow down output and growth. Following that comes a phase of rebuilding where stock of capital is used to rebuild, during that period there is increased activity leading to more growth. After older damaged and destroyed physical capital has been rebuilt output will increase even more as a result of the updated machinery. The time it takes to regain former output levels depend on the severity of the disaster and preparedness for it, but usually range between 9-18 months, while GDP growth will increase faster. After which output will continue at an increased rate until the rebuilding phase is complete. This is based on observations and proved to be the case in Kobe 1995 where Kobe had been in a slump, in 1994 the GDP growth had been 0,6% but in 1995, the year in which the earthquake struck in January, the GDP grew by 1,4% (Horwich, 2000). Long term growth on the other hand depends on the type of disaster; climatic or geological, which have different effects as climatic ones are more predictable than geological.

Geological disasters are disasters such as earthquakes, tsunamis, avalanches and volcanic eruptions while climactic disasters are among others: floods, cyclones, hurricanes and

tornadoes. The main differences between those two types of disasters are the frequency and predictability of them. Floods for example are much easier to predict and occur more frequently than volcanic eruption which makes it possible to protect yourself and prepare for them. Also for this reason climactic disasters tend to cause fewer casualties than geological ones (Skidmore og Toya, 2002).

Geological disasters add nothing to the long term growth of a country but neither do they decrease it whereas a climatic disaster increases it (Skidmore og Toya, 2002). Due to the definition of climatic disasters, the Touhoku earthquake in Japan could be classified as a climatic one although its default definition would be a geological disaster. Large destructive earthquakes hit Tokyo about every 70 years, and this has been the trend for the last 400 years. Even if they can't prepare for it like you could for a flood it is a well-known fact for Tokyoites that large earthquakes will hit every roughly 70 years. During the author's stay in Tokyo from 2005-2006 he was regularly told that the big earthquake was late and this might be the year it finally strikes, this earthquake in not sneak up on Japan. To add to that about 30% of Japanese private savings are earmarked for rebuilding in the aftermath of a disaster (Horwich, 2000). The definition of the Touhoku earthquake as geological disaster can be challenged on the grounds that it was expected and people had been preparing for it, at least it can be said that it does not clearly follow the definition of geological disaster. Owing to that it is inconclusive whether or not the after effect should be those of a climactic or a geological disaster.

There is a trend among countries that suffer frequent natural disasters to invest more heavily in human than physical capital (Skidmore og Toya, 2002). As formula (8) showed this trend does seem to lead to a faster long term growth than with focus on investment in physical capital because of the added multiplier effect it has on the technological level as well as the intergenerational spillover effect it has causing human capital to grow faster as more investment in human capital is added. So even if it can't be said for certain whether or not the Touhoku earthquake will have no or positive effect on the growth of Japan in the long run it can be said that since natural disasters like the Touhoku earthquake are frequent in Japan they have adopted an investment trend that does lead to an increased growth.

Conclusion

On the average it seems as though a natural disaster will lead to a GDP growth, both in the short and in the long-term and the Touhoku earthquake should be no exception to that. Japan is no stranger to natural disasters and was financially prepared for this disaster which is paramount in these situations. With their high marginal propensity to save and a high percentage of that saving set aside for rebuilding in the wake of a disaster the Japanese people have effectively self-insured themselves with their private savings. The over $30 billion payout they will receive from insurance plus the $50 billion relief package from the government might also go a long way in rebuilding Japan, not to its former glory but perhaps even beyond it. As production sites and factories are rebuilt there will be an adoption of new technology resulting in a high amount of updated machinery and production methods which should lead to an increase in manufacturing output. While this still hasn't been rebuilt production can be allocated to plants or manufacturing sites that are not working at full capacity to fill in the shortages in supply. While there is still a lack of physical capital the combination of resources can be altered and labor added to compensate for the missing machinery. Once physical capital has been rebuilt the output should be higher and again higher still with the gradual increase due to the Horndal effect. Rebuilding should not take as long a time as building as there isn't as much time needed for planning and evaluating needs, earlier investment patterns can be copied with some alterations for optimal use of the area with regards to the new technology and earlier experience. The only worrying factor in this respect is the possibility of a diminished power supply as a result of the closed nuclear plants. The biggest business lobby in Japan though has instructed its members to cut down power usage by 25%, probably more than is needed even over the peak time, which should result in enough power for manufacturing to go on unhindered. With the estimated time for recovery of production output predicted to be late 2011 the outlook for the reconstruction of Japan looks promising.

While the Japanese stock market fell by about 16% in the week following the earthquake it was up to 94,5% of its pre-disaster level only three months later, with that trend and the Kobe earthquake as a historical lesson we should see it back at its normal pace in about a year. Now with Japan in line with the global price levels the increased activity in Japan from all the rebuilding and the increase in production Japan is likely to experience a healthy inflation after more than a decade of deflation, this would be a big change for Japan but should set it more along the trends of other first world economies. The yen is expected to

remain relatively stable, with the government keeping a close watch on it and with the earlier intervention of the G-7 it is unlikely to appreciate but might possibly depreciate making Japan more competitive as a country to import from. There might be a tax increase introduced to Japan but as long as it is an income tax and not a sales tax and a modest amount it shouldn't hamper growth too much. The best option in the author's opinion would be to borrow from abroad but with the general public support for the tax increase and as long as it is a modest amount it may not be too bad. With the massive rebuilding effort now underway and private savings, a government relief packages and insurance money amounting to hundreds of billions of dollars being pumped into the economy it will lead to a multiplier effect, a higher income and increased spending that might just counter act the decreased spending from the higher tax. The result from this should be a faster GDP growth rate than before, if not this year then at least in the year following and estimates say for at least four years more. In the short term this increase will stem from the increased investment in physical capital, the rebuilding efforts and the increase in spending it will lead to. In the medium term there should be a growth from the added output from the new machines and procedures adopted as well as the added multiplier of the Horndal effect. In the long-run Japan should again resume earlier investment patterns moving from physical capital to investment again into human capital resulting in faster increase in the technology level and the multiplier effect from the intergenerational spillover effect leading again to a faster growth in output. This leads us to answer the research question: "Will Japan experience increased growth following the Touhoku earthquake?" that Japan is likely to experience increased growth from the Touhoku earthquake in the short, medium and long-term.

Discussion

There is one scenario that was not studied in this thesis and that was what would happen if the Fukushima Daiichi nuclear power plant would explode. In the unlikely event that it would actually happen there is just too little data to go on, comparing it to Chernobyl would not be accurate and all of the research that would be needed would not fall under the field of business but rather possibly environmental engineering or studies. The effects of the nuclear power plants had to be confined to the more probable events of it remaining relatively confined to the plant area. There has some radiation been measured in leafy vegetables in the surrounding area but any studies into the level of radioactivity and measures that are likely to

be undertaken to prevent them from being persistent in the vegetables is far beyond my field of knowledge. I had to base all estimations on the scenario where the radiation itself would not provide enough damage to disrupt the economy, I instead focused on the fact that this might lead to power shortages. On the subject of power shortages, as was mentioned in the "Effects of GDP" chapter Japan might suffer some shortages in power supply, but with efforts such as restarting older fossil burning plants. I did not go into the subject of buying power from abroad although that is always a possibility, how Japan is tackling this matter is very interesting and the efforts like cutting 25% of power usage by using less air conditioning and other creative measures is ingenious. The model that I present as formula (8) is not a finite interpretation of investment possibilities and all possible effects thereof. It is merely a model to demonstrate the short and long-term effects that investment into human and physical capital has. Some other growth models use total factor production in lieu of the technology level, I chose to use technology level instead since the multiplier effect of investment into human capital does not affect all of the total factor production but only the technology level. There have not been too many academic studies into the topic of growth and natural disasters and with no real models or tools that could be used argumentation had to be relied heavily upon as well as having to develop my own model. Skidmore and Toya have done some interesting studies into this topic though and most of my academic references into this subject came from them. Other authors themselves such as Tol and Leek have noted on the difficulties that come from studying this subject with the lack of real models to rely on. The most difficulty with writing this thesis is the short amount of time since the Touhoku earthquake happened. Work on this thesis began less than a week after the earthquake struck, while this thesis was being written new information was being released regularly, the full extent of the effect of the earthquake will probably not be seen until a decade from now. Then again this is not a study in what has already happened but what is likely to come.

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