

Impacts of a Potential Influenza Pandemic on New Zealand's Macroeconomy

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Summary

New Zealand and the world currently face the risk of a global influenza pandemic caused by the potential adaptation of avian influenza H5N1 to humans. This paper investigates the possible effects of a pandemic on New Zealand's macroeconomy. Although the economic effects may be dwarfed by the social and human costs of death and illness, it is still important to evaluate how a pandemic may affect the economy so as to guide policy interventions to lessen the economic impact. Our approach is to model the impact of a pandemic as simultaneous supply and demand shocks. Supply shocks arise primarily from workers stopping work due to sickness, care of others, or fear of infection. New Zealand's import supply may also be disrupted. The labour force would be permanently reduced due to deaths caused by influenza. Demand shocks arise due to lower export demand, higher uncertainty, "social distancing" caused by fear of infection and public health measures, and consequential effects on income. There is a great deal of uncertainty around the potential size of these shocks. However, the results of this paper do suggest that a severe pandemic has the potential to generate a significant loss of output and income growth.

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Motivation and Key Results

Experts at WHO and elsewhere believe that the world is now closer to another influenza pandemic than at any time since 1968.

The World Health Organisation (WHO) has warned that the world currently faces a higher risk of a global influenza pandemic that at any time since the 1968 influenza pandemic. This risk is mainly due to the spread of the H5N1¹ strain of avian influenza among birds and other animals in Asia, the Middle East, Africa and Europe. A combination of other factors also contributes to the WHO's concerns, including the dynamics of resistance to influenza within populations and the emergence of conditions conducive to the global spread of a severe influenza virus.

In response, governments across the world are, in varying degrees, considering their states of preparedness, promoting research into development of an effective H5N1 vaccine, and promoting international cooperation to contain the spread of the H5N1 virus.² In New Zealand, the Ministry of Health (2005) has prepared an influenza pandemic plan, and the Ministry of Economic Development (2005) has provided information for businesses and other organisations to assist with their preparedness.

The purpose of this paper is to provide an assessment of the potential impact of an influenza pandemic on New Zealand's real Gross Domestic Product (GDP). This assessment work was prepared as a contribution to interdepartmental work on pandemic planning (The Treasury 2005). The approach used in this assessment is to model the impact of a pandemic as a simultaneous supply and demand shock. The supply shock arises primarily from a reduction in labour supply as labour is withdrawn to minimise the risk of infection, to recover from infection, or as a result of death. There may also be disruptions to the supply of imported intermediate inputs to production. The labour supply effect in particular differentiates pandemics from other types of shocks. The highly contagious nature of influenza and the speed with which it can spread mean that, in a modern economy, labour withdrawal is an essential part of the process of "social distancing" that is required to reduce the risk of infection and minimise contagion. Here we use the term "social distancing" to refer to any action by people to avoid infection from other people, including for example not using public transport or staying home from work. This process of "social distancing" directly contributes to reduced availability of services and reduced consumer demand.

The demand shock arises primarily from reduced international demand, and from reduced domestic demand due to rising economic uncertainty,

¹ H5N1 refers to the gene coding of the virus. Virologists use the combinations of antigens (haemagglutinin, which comes in sixteen known basic shapes, and neuraminidase, which comes in nine known basic shapes) to identify a particular virus. H1N1, for example, is the name for the influenza virus that caused pandemic in 1918.

² The World Bank, the World Health Organization, the Food and Agriculture Organization, and the World Organization for Animal Health are taking the lead in preparing a global coordinated response strategy on the possibility of an avian flu crisis, and helping members improve surveillance and control capacity and to develop national action plans that focus primarily on human and animal health (International Monetary Fund 2006).

reduced household income and “social distancing”. As the pandemic passes, we assume that GDP gradually recovers to its long-run path, which in turn is likely to have been affected by the impact of the death rate on the size of the labour force.

“Given the unpredictable behaviour of influenza viruses, neither the timing nor the severity of the next pandemic can be predicted with any certainty.” – WHO

This paper *does not* consider the likelihood of an influenza pandemic around which there is still considerable uncertainty. Uncertainty exists because we cannot be sure whether the H5N1 virus will mutate into a form that can be transmitted from human to human nor whether international cooperation can contain the spread of a mutated virus. However, even if a pandemic involving the current strain of H5N1 does not eventuate, the risk of pandemic from other influenza viruses remains.

There is also inevitably considerable uncertainty involved in assessing the potential economic impact of an influenza pandemic should one eventuate. An influenza pandemic is unlike other shocks that typically impact on New Zealand’s economy and there has been scant international research on the economic impact of previous pandemics. In any event, differences in the epidemiological features of influenza viruses and differences in the environment in which a future influenza outbreak will occur make comparisons with previous pandemics difficult. There have been marked changes for example in the speed and pervasiveness of global travel and trade, the capability of public health systems and availability of antibiotics, and in international monitoring and awareness since the influenza pandemics of 1918, 1957 and 1968.

We base our assessment on judgements about the magnitudes of the supply and demand effects. Due to the uncertainty surrounding potential pandemics there are many different scenarios that could be investigated. We look particularly at the severe scenario presented by the Ministry of Health and Ministry of Economic Development in their planning documents, and at a less severe scenario based on the features of the influenza pandemics of 1957 and 1968. These two scenarios do not represent upper or lower bounds for the potential impact on the economy.

For the severe scenario we first assume that 40% of the population become infected with the virus and 2% of the infected die, giving a population death rate of 0.8%. On top of this we assume another 40% of the workforce takes time off work due to fear of infection or care of others. The wave of infection occurs over an eight-week period, with the greatest infection rates in the third, fourth and fifth weeks. Considering as well a range of demand reductions and business closure rates, we estimate the impact of a severe pandemic in New Zealand to be in the range of a 5 to 10% reduction in annual real GDP in the year of the pandemic. Over four years we estimate the cumulative reduction in real GDP to be a loss of 10 to 15% of one year’s GDP. The range of estimates for the economic impact depends on the extent that consumer demand is reduced by the pandemic and the extent that industries choose to or are forced to close because of public health measures. A large proportion of the estimated reduction in GDP is due to reduced GDP during a recovery period following the pandemic. If

the economy recovers faster or slower than we have assumed the impact may be considerably smaller or larger.

We also investigate a pandemic with a lower infection rate and case fatality rate. For this scenario we assume the effect on the labour supply and on consumer demand is less, although we note that a pandemic being epidemiologically less severe does not necessarily mean the length of time people take off work or the psychological effects of the pandemic are lessened. A pandemic with an infection rate of 30% and a 0.25% case fatality rate would have a mortality rate of the same order of magnitude of the 1958 and 1967 pandemics. If the associated labour withdrawal and “social distancing” effects are indeed reduced, a pandemic of this magnitude could have considerably less impact and may reduce GDP by the order of 1 to 2% in the first year, an impact similar to a typical business cycle downturn.

Background

In New Zealand, around 5% of adults and 20% of children suffer from an influenza-like illness in a typical year. The spread of influenza is usually limited by immunity among the population due to past infection or vaccination. However, if a new influenza virus emerges that people have little or no immunity to, it can spread rapidly infecting large proportions of the population in a short space of time and in some cases cause a pandemic. During the last three centuries influenza pandemics appear to have occurred on two or three occasions each century (Appendix pp 60-61 Woodson, Baker, Roberts and Jennings 2005). This pattern is thought to reflect the instability of the genetic structure of influenza viruses and the corresponding variation in resistance to influenza within populations.

Pandemics in recent times are considered to have originated in East Asia and spread across the world involving a process that can take several years. The 1957 “Asian flu” for example started in China and via Hong Kong’s nexus of trade routes the virus spread rapidly throughout South East Asia then to Europe and North America. The 1968 “Hong Kong flu” is also thought to have originated in China and spread to other parts of the world through Hong Kong. Its diffusion pattern was different to the 1957 pandemic, probably reflecting the increase in air travel. The origin of the virus that caused the global pandemic of 1918 is less clear (Taubenberger and Morens 2006).

The current risk of a global influenza pandemic is largely due to the spread of avian influenza (H5N1 in particular) among birds and other animals in Asia, the Middle East, Africa and Europe. The H5N1 virus was evidently first identified in South Africa in 1961 and until recently there had been no human cases of the disease (Barry, 2004). The first known infections of humans occurred in Hong Kong in 1997 killing six of the eighteen known victims. Crisis management by the Hong Kong government contained the spread of the virus. Nevertheless, circulation of the virus in wild birds has resulted in further outbreaks. Despite the slaughter of millions of poultry

the virus is now endemic in many parts of Asia and has recently been discovered in parts of Europe, the Middle East and Africa. By March 2006 outbreaks of H5N1 among poultry, wild birds and other animals had been confirmed in 45 countries (World Organisation for Animal Health 2006).

Although the H5N1 influenza virus's natural home is in birds, exposure to the virus can infect humans directly. However, avian viruses do not typically transmit from person to person, to do so they must mutate or exchange genes with another virus that can spread between humans. Recent evidence suggests that the less severe pandemics of the last century, in 1957 and 1968, were caused by viruses with genes from both human influenza and avian influenza viruses (October 22, *The Economist* 2005). Recent research also suggests that the H1N1 strain of influenza that caused the severe 1918 pandemic was a strain of avian flu (Gamblin *et al.* 2004).

According to Dr Julie Gerberding, Director, Centers for Disease Control and Prevention, "For an influenza virus to cause a pandemic, it must meet three major criteria: (1) possess a new surface protein to which there is little or no pre-existing immunity in the human population; (2) be able to cause illness in humans; and (3) have the ability for *sustained* transmission from person to person. So far, the H5N1 virus has met two of these three criteria, but it has not yet shown the capability for sustained transmission from person to person."³

More than half of those known to have been infected with H5N1 died as a result.

As of 24th of March 2006, 186 people were known to have been infected with the H5N1 virus since 2003, and 105 people have died as a result (World Health Organisation 2006). These infections have occurred as a result of contact with infected birds, there is no evidence that the virus has mutated into a form that could be transmitted between humans. If human to human transmission does occur, there is potential for the virus to cause a global influenza pandemic as humans would have little immunity to the new influenza strain.

Evaluating the potential human and economic cost of such a pandemic is however fraught with uncertainty. There is epidemiological uncertainty about whether H5N1 will develop the ability for sustained transmission from person to person and if it does, there is uncertainty about the potential infection rate and case fatality rates. Historically influenza pandemics have had infection rates ranging between twenty and forty percent (Taubenberger 2005). Michael Osterholm, Associate Director of the US Department of Homeland Security's National Centre for Food and Defence, takes the view that recent clinical, epidemiological, and laboratory evidence suggests that the impact of a potential pandemic caused by the current H5N1 strain could be similar to that of the 1918 pandemic (Osterholm 2005). The 1918 flu is believed to have killed around 50 million people

³ Testimony of Julie L. Gerberding before the Subcommittee on Health, Committee on Energy and Commerce, U.S. House of Representatives, May 26, 2005

worldwide⁴, and was particularly lethal for people in the 20 to 40 year age bracket. Total deaths in New Zealand attributed to the pandemic are estimated to have been close to 8,600 (Rice 2005, p221), in excess of 0.8 percent of the population.

There is little research on the economic effects of past influenza pandemics.

As a result of epidemiological uncertainty and significant differences in social, political and economic conditions prevailing during previous pandemics there is inevitably uncertainty about the potential economic impact of a pandemic. Despite the severity of the impact of the 1918 pandemic on human life, there is scant international research available evaluating its economic impact. Although recent research suggests there may be long-run economic effects of pandemics, the conclusions from this strand of research are unclear (Almond 2005, Bloom and Mahal 1995, Brainerd and Siegler 2003). Nevertheless, estimates by Lee and McKibbin (2003) of the economic impact of the Severe Acute Respiratory Syndrome (SARS) outbreak in 2003 suggest that the short-run disruption to GDP growth of a pandemic could be significant. Similarly, despite a comparatively low infection rate, Cooper and Coxe (2005) estimate that the outbreak of SARS in Toronto reduced annual Canadian GDP by as much as 0.6 percentage points.⁵

The impact of previous pandemics on the New Zealand economy has received little attention. Official reports on the 1918 pandemic by the Influenza Epidemic Commission (1919) and by Mackgill (1919) concentrate on infection and mortality rates and the public health sector response to the crisis. In a comprehensive account of the course of the 1918 influenza pandemic in New Zealand, Rice (2005) comments that there was widespread public criticism of the Government's handling of the pandemic, in particular the delay in taking seriously the potential threat of the virus, casual and ineffective quarantine restrictions, and inadequate coordination between central and local agencies. These factors may have contributed to a higher infection and death rate in New Zealand than in Australia.⁶

Nevertheless, despite relatively high infection and death rates in New Zealand, Rice proffers the view that the cost of additional health care was insignificant and the cost to the business community was moderate. He notes that "The financial year 1918-19 showed a lower profit than usual, from lost sales and production, but there were no dramatic business collapses attributable to the pandemic." And that "the economic effect of the epidemic seems to have been incidental because it was over so quickly" (Rice 2005, p 259).

⁴ This estimate is from Johnson and Mueller (2002) who note that successive estimates have continuously raised the death rate from the 1918 pandemic estimate as more reliable records have come available, prompting some to suggest that the death toll may have been even higher and closer to 100 million.

⁵ In Toronto the infection rate was comparatively low, 252 people were infected and 44 people died. The majority of the economic impact came from heavily reduced tourism and the disruption to normal business because of quarantine and health concerns.

⁶ Australia adopted for example a more vigilant approach to quarantining ships. Although Australia was still unable to prevent the outbreak of the pandemic, it occurred later and the death rate in Australia was estimated at less than half that for New Zealand (Rice, p 253).

Unusual conditions prevailing in 1918 no doubt accentuated the spread and virulence of the “Spanish flu”,⁷ notably the war conditions, the priority given to the war effort, the lack of international cooperation, and lack of preparedness and information available to the public.⁸ However, a number of factors suggest that a similar outbreak could today have more severe economic effects. While international monitoring and cooperation are now more effective, the rapid growth in international trade and travel and the vastly larger numbers of at risk animals and poultry in Asia have increased the risk of global contagion. The risks of contagion within New Zealand have probably also increased significantly since 1918 and perhaps in ways that have accentuated the need for “social distancing” and therefore the potential economic cost of a similar type of influenza outbreak. In particular, greater urbanisation of the population and the growth of services have increased person to person contact on a daily basis. In 1916 approximately 29% of the labour force was employed in the primary sector and about 54% of the population lived in rural areas, where the risk of infection was probably lower. In 2001 only 8% worked in the primary sector and only 14% lived in rural areas.

Conceptual Framework

The impact of a pandemic can be evaluated in terms of the loss of life and other human costs, the economic impact, and the social and political implications. These impacts are interrelated. Here we focus on the economic costs, and specifically the reduction in GDP resulting from a pandemic. In doing so, we assume no serious disruption to social relations and social order. A breakdown in social order could be expected to accentuate the economic impact of a pandemic and disrupt the recovery.

The effect of a pandemic will occur in four stages ...

The impact on GDP growth can be broken down into four stages: the anticipation stage; the direct impact stage when the pandemic occurs; the recovery from the impact stage; and the fourth stage is the long term effect. If a pandemic has multiple waves of infection the distinction between these stages will be less clear than for a pandemic that occurs in a single wave.

This framework could be used to evaluate the impact of most exogenous shocks to an economy’s GDP growth. The four stages would however vary according to the type of shock. For example, climate shocks in New Zealand tend to impact through primary production and electricity generation. Furthermore, they tend to come with less warning and any

⁷ Although commonly referred to as the “Spanish Flu”, the 1918 influenza pandemic is thought to have started in Kansas in early 1918 and was transferred to US Army cantonments. From there it followed troop movements to army bases throughout the US and to Europe. It spread through Europe, including Spain, infecting the Allied and German troops. By June and July it had reached Greece, Bombay and Shanghai. In September it reached Australia and New Zealand. Spain, being a neutral country, was the first to officially record and report the spread of the influenza virus and hence it was referred to as the “Spanish Flu” (Chapter 14, Barry 2004)

⁸ See for example Barry (2004) and Rice (2005) for discussions of the responses by government officials in the USA and in New Zealand to warnings by medical professionals about the risks of troop transfers, to conditions in army camps (where infection and death rates were particularly high), to the need for public awareness and the risks of public parades in support of the war effort and in celebration of the armistice.

anticipatory behaviour would likely be built into normal institutional arrangements and behaviour. Terms of trade shocks come through relative price changes and can be anticipated if there is for example a systematic relationship between world business cycles and commodity prices. Modelling these types of shocks is somewhat easier because they are recurring and can be estimated statistically using historical data.⁹

... the anticipatory stage ...

The anticipatory stage occurs because pandemics typically give warning signs. As the editorial in *Nature* recently stated “The maths of epidemiology says that pandemics are like fault lines: they inevitably give. But unlike earthquakes, pandemics tend to give warning signs, and all the alerts from Asia are now flashing red” (Nature Editorial 2005).

This stage involves households preparing for medical shortages, and hoarding food and other supplies to overcome potential difficulties in safely accessing them during a pandemic. Businesses normally reliant on “just-in-time” supply chains and overseas supplies may decide to build inventories in anticipation of supply shortages or seek alternative sources. To the extent supplies are produced or have value-added domestically, this behaviour would raise domestic demand and GDP. This impact would be accentuated if the likelihood of a pandemic increased. An increase in imports during this period may increase the trade deficit, but this may be offset by similar anticipatory behaviour in other countries. There is also the prospect of world consumer demand substituting away from poultry to demand for New Zealand’s proteins, lamb, beef and dairy products.

Anticipatory behaviour may also have a negative impact on GDP if the expectation of a pandemic caused consumer and business confidence about future income growth and future sales to decline. If an outbreak of pandemic influenza occurs in another country, firms may defer investment until after a pandemic has run its course.

... the direct impact ...

The second stage involves the direct impact of the pandemic occurring in New Zealand. During this stage the impact on the economy will come through both the supply side and the demand side. On the supply side the output of the economy will be reduced as workers stay home sick or afraid, businesses close for health reasons, and the supply of intermediate inputs through international trade is disrupted. On the demand side the economy will suffer reduced domestic consumer demand and reduced demand for exports due to lower domestic and world incomes during the pandemic and also because of “social distancing” resulting from health concerns. In particular, service industries, including tourism and education services, will be acutely affected as people avoid gathering in public or leaving their homes. For some parts of the economy, such as the health sector, demand may increase, but we expect these effects to be small in comparison to the aggregate reduction in demand for goods and services.

⁹ Using for example the procedures used in SVAR models of the New Zealand economy, summarised in Buckle, Kim, Kirkham, McLellan and Sharma (2003).

Overall these demand side and supply side reactions will cause a reduction in the rate of employment and production, and hence GDP. In the short term there would also be considerable uncertainty about future asset values and reduced cash flow for firms and households. The threat to population growth would likely impact adversely on the housing market. These factors could put pressure on financial institutions and could accentuate the initial impact. The IMF also cautions that “aside from sharp changes in asset prices, operational risks constitute the greatest challenge to the global financial system in the event of a severe pandemic” (International Monetary Fund 2006). The IMF stresses the need for contingency planning by financial institutions to ensure their proper functioning in the face of high worker absenteeism. Exchange rate and interest rate changes could help ameliorate the initial impact effects, as could fiscal policy.

... the recovery ...

The third stage is the transition back to the long run potential output of the economy after the pandemic has run its course. The speed and nature of the recovery is very uncertain due to the lack of information about the recovery from past severe pandemics. The recovery path will depend crucially on a number of unknowns. In particular, it will depend on the reactions of business and consumer confidence, and the effects on consumer demand and business investment. It will also depend on how asset prices and household wealth are affected, the reaction of the global economy, the reaction of exchange and interest rates, and changes to expected population dynamics.

The way the pandemic affects wealth will depend on how resilient the housing and financial markets are to the initial shock. If a large reduction in wealth were to occur due to a market collapse, this would be felt for several years in reduced consumer demand. Furthermore, the recovery of New Zealand’s tradable goods and services sector will be crucially influenced by the how badly the rest of the world was initially affected, and the length of time international demand takes to recover.

... and the long term impact.

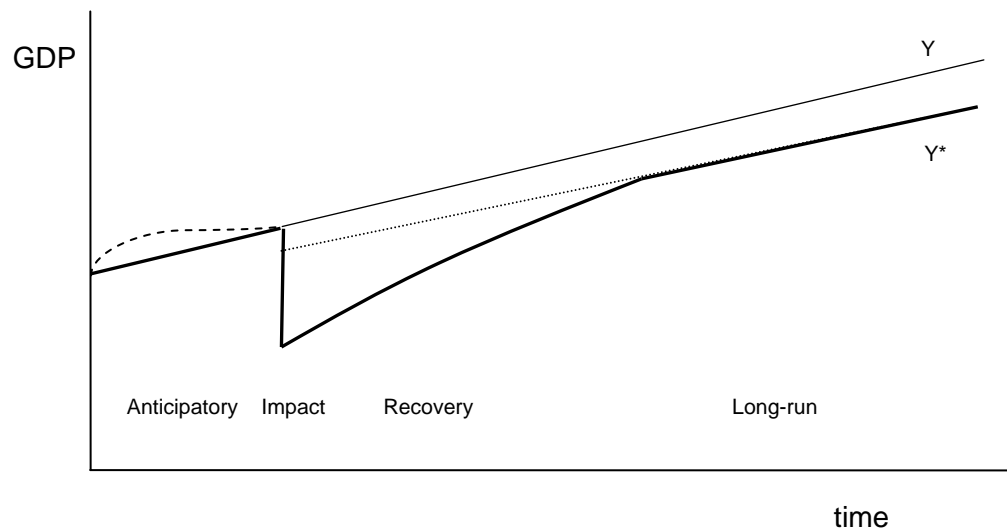
The fourth stage is the long term impact on the economy and the rate of GDP growth. This long-term effect will depend on the pandemic’s impact on labour force growth and on labour productivity growth. In the medium term any drop in population will reduce the potential output of the economy. But it is uncertain just how a pandemic will affect future population dynamics and labour force growth, and therefore whether the initial decline in potential would be offset by future fertility growth. A pandemic that has particularly high mortality rates for the 20-40 age group, which was the case in 1918, is likely to negatively affect population fertility rates (Brainerd and Siegler 2003).

The impact on labour productivity is also uncertain. A study by Almond (2005) of the impact of the 1918 pandemic showed those *in utero* during the pandemic displayed, in childhood and adult life, reduced educational attainment, increased rates of physical disability, lower income, lower socioeconomic status and accelerated mortality. This suggests that a pandemic could have adverse effects on future labour productivity. On the

other hand, a reduction in population, other things equal, could result in an increase in the level of physical capital per worker if investment was sustained. This capital deepening effect may raise labour productivity. The reduction in population may also impact on aggregate savings. All these potential reactions are uncertain and hence the long term growth path is also uncertain.

Figure 1 shows the various stages involved in the pandemic shock. In this figure the long-run GDP path Y is the path without a pandemic shock. Because of the pandemic, during the impact stage there is an initial reduction in output from the economy's long-run path. Over time, the economy recovers back to the long-run potential path. However, we assume in our estimations that the potential long-run output is now lower due to death, shown by the long-run GDP path Y^* (assuming labour productivity growth remains unchanged). In Figure 1 we have shown the anticipatory stage to have a positive effect on GDP, but as noted above this could either be positive or negative depending on the extent that confidence is decreased by an impending pandemic.

Figure 1: Pandemic shock and recovery to reduced baseline GDP



While we focus throughout this paper on the reduction in the level of aggregate GDP, the impact on GDP per capita will be lower due to the reduction in population during a pandemic. The effect on long run GDP per capita will depend on the pandemic's effect on labour productivity, which as discussed above is difficult to predict.

Assessing the Impact of a Pandemic in New Zealand

We concentrate on the direct impact of a pandemic and the recovery.

This evaluation of the impact on GDP concentrates on the second stage, the direct impact of a pandemic, and the third stage, the mid-term recovery. We assume the first stage anticipatory effects are either small or tend to be offsetting once the direct effects of the pandemic unwind. Our estimation of the direct impact is simple and does not include all the effects noted above. In our treatment of the recovery we assume no change in long-run labour productivity growth. We assume that the economy gradually converges to a long-run path with a lower population and therefore lower labour force (potential GDP in each future period being reduced by the assumed mortality rate of the pandemic).

We estimate the impact of a pandemic at a nationwide aggregate level. We do not consider effects on particular regions. We assume that the pandemic takes eight weeks and that it occurs in one wave of infection. The 1918 pandemic occurred in three waves, where the second wave was the most deadly. The economic impact of a multiple wave pandemic may be higher than a single wave pandemic because the disruption to normal life will occur over a much longer period. It is impossible to predict the number of waves a pandemic will have, so we have chosen one wave and in this sense our estimates may be conservative.

We also assume that during a pandemic normal social relations will continue (i.e. no riots and the continuance of normal law and order), and that infrastructure and utilities continue to operate. If any of these assumptions fail to hold the impact will be different and most likely more severe. It is also assumed there is no long term impact on the structure of the world and New Zealand economies. Another assumption we have made is that the pandemic occurs in New Zealand at approximately the same time as for the rest of the world. If it occurs significantly later in New Zealand, we could suffer from a period of disrupted trade and low confidence before the pandemic arrives. This would prolong the overall impact of a pandemic, but may allow time for the development of a vaccine that would lessen the cumulative impact.

As discussed above we estimate the reduction in GDP due to the pandemic in two stages, the direct impact during the pandemic and recovery from the direct impact. To estimate the direct impact we look at expected reductions in GDP due to three sources:

- the lost output due to people being away from work;
- the temporary reduction of output from industries due to reduced demand, or closure of businesses due to health reasons; and
- the permanent reduction in potential GDP due to death.

The lost output due to people away from work is estimated from the sickness rates generated by the planning model developed by the Ministry of Health and assuming an additional absenteeism rate. To calculate the impact of workers being away for sickness and absenteeism reasons we assume that a 1% reduction in the labour supply leads to a 0.6% reduction in GDP. We assume the relationship between reduction in labour supply and output is less than one-to-one because capital is unaffected. Most of the labour supply reduction is temporary in nature and we assume there will be a compensating increase in labour productivity. This is very likely the case for small reductions in labour supply, but may not necessarily be the case for the large reductions this paper considers, and therefore our estimates may be conservative for a severe pandemic. We do not know in which season the pandemic might occur, and therefore ignore seasonal changes in GDP.

The economy wide reduction in output due to reduced demand or closure of industries is calculated by aggregating estimated reductions in output for each industry. Because it is unclear exactly how much demand will be reduced for each industry we investigate a number of different cases. For all our calculations we assume the *measured* output in the government sectors of the economy and in health and education does not change during the pandemic. The measured output of these sectors is primarily based on the level of funding, and this is unlikely to change during a pandemic despite likely decreases in actual output.

The lost output due to death is taken into account as a permanent reduction in the level of GDP, in the severe pandemic case a 0.8% reduction in the level of potential GDP. In our estimation of the initial shock to GDP we do not make an in-depth analysis of multiplier effects of reduced demand or supply in particular industries on the economy as a whole. Instead we look at a number of demand and closure impacts.

Note that some of the reduction in GDP due to demand side effects will already be accounted for in the supply side calculation. To avoid double counting we have at any time taken the reduction in GDP to be the maximum of either the supply side or demand side effect. This assumes that labour resources can be reallocated in industries so that supply reductions occur in the areas of reduced demand. In this sense this is a minimum estimate of the impact as reallocation may not be possible, especially for the short time scale of a pandemic.

Following the initial decline in GDP, the economy is expected to recover to the baseline level of GDP (minus the potential lost due to death). We assume the recovery follows a path generated by the New Zealand Treasury Model (NZTM) developed by Szeto (2002). NZTM is a computable general equilibrium model of the New Zealand economy. It is a three-good, small open economy model featuring a well developed production block that has been econometrically estimated. The model has a two-tiered structure: a steady state version of the model is used to estimate the equilibrium exchange rate and potential output, and a dynamic version of the model that traces the response of macroeconomic variables

to various shocks. There are four behavioural sectors in NZTM: the private business sector, the household sector, the external sector and the government sector. The interaction between these sectors is fully described in Szeto (2002).

The main use of NZTM is to understand and forecast how the economy responds to shocks. In general, the economy would move along an equilibrium growth path in the absence of shocks, and shocks from both the demand and supply side of the economy will push the economy away from the equilibrium growth path. Even when a shock lasts for a short period, the impact of the shock on the economy can persist over a much longer period of time as there are a great deal of interdependencies within the economy, both across sectors and over time. The strength of NZTM is to provide a consistent framework to analyse how the economy returns to the equilibrium growth path after a shock as in Figure 1.

In order to generate a recovery path in NZTM for the economy after the initial pandemic impact, we impose temporary shocks on both the demand side and the supply side of the NZTM model to generate an initial reduction in GDP of the order of the initial reduction calculated from our initial impact calculation. This recovery path is then scaled for each different initial impact we consider.

It must be noted that the historical shocks used to calibrate NZTM are quite different to the severity and nature expected from an influenza pandemic. A pandemic shock is outside normal experience and the recovery path generated using NZTM may not therefore accurately represent the potential recovery path. We use NZTM's recovery path only as a first approximation. Unfortunately there is little available research evaluating the impact and rate of recovery from pandemics to inform this work.¹⁰

One modification we do make to NZTM is the treatment of fiscal policy in the recovery stage. The fiscal rule in NZTM normally allows tax rates to adjust to ensure a public debt target is maintained. This would imply that, for a given government expenditure path, tax rates would have to rise during a pandemic to sustain the debt target. In the simulation shown in this paper, we relax the public debt target constraint and allow debt to increase. We have not adjusted NZTM's monetary policy rule, which assumes the central bank adjusts short-term interest rates to achieve an inflation target of 2.0% per annum over the medium term.

Estimated Impacts of a Severe Pandemic

Our estimation for a severe pandemic is based on the population infection and case fatality rates of the standard planning model pandemic developed by the Ministry of Health and adopted by the New Zealand Government for pandemic planning purposes.¹¹ The standard planning model assumptions are based on the infection and case fatality rates of the 1918 influenza

¹⁰ One exception is Brainerd and Siegler (2003).

¹¹ See appendix 3 of Ministry of Economic Development (2005).

pandemic in New Zealand, that is a 40 percent infection rate, with a 2 percent case fatality rate, giving a population mortality rate of 0.8%.

As well as the sick, we assume that there is a 40% additional absenteeism rate. We assume workers take an average of three weeks time off work, resulting from the Ministry of Health's assumption that each sick or absent worker takes 1.5 weeks off and that an additional 15% of the working population takes 8 weeks off to care for children who cannot go to school. Because we do not know which parts of the working population will be affected, we assume the infection and absenteeism rates are uniform across all workers.

Using these planning assumptions and considering a range of demand reductions and industry closure rates and applying the quarterly recovery process generated by NZTM, we estimate the impact of a severe pandemic in New Zealand to be broadly in the range of 5 to 10% reduction in real GDP in the year the pandemic occurs. Over 4 years the cumulative reduction in real GDP is broadly in the range of 10 to 15% of one year's GDP.

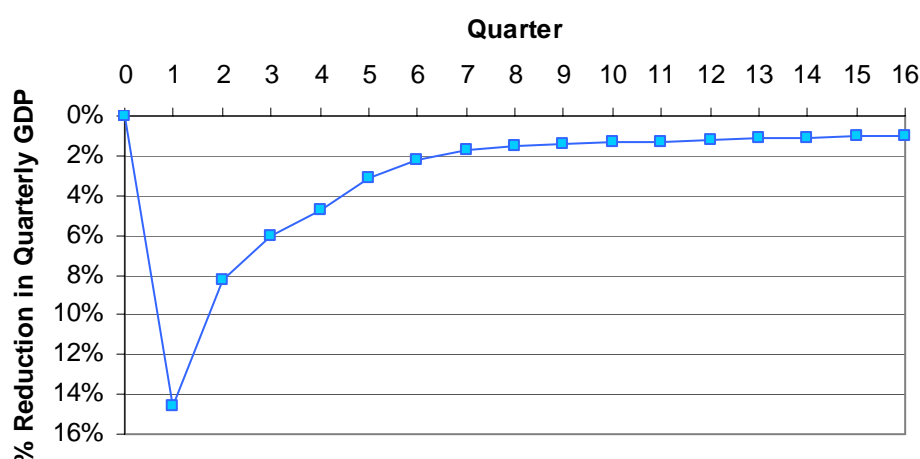
This range of GDP reductions comes from a series of increasing reductions in the output of industries. To begin with we assume there is no reduced demand or closure for any industries, there is simply a fall in supply of labour as a result of sickness, absenteeism and death. As a second step we assume that output from the Accommodation Restaurants and Bars, Cultural and Recreational Services, Personal and Other Community Services industries is reduced by 75% in the pandemic quarter. These industries make up approximately 5% of the economy. Further, we assume that Retail Trade output is reduced by 25%. These reductions in output will be the result of health restrictions on public gatherings, the decline of the tourism industry, and drops in demand as people confine themselves to their homes. We also assume a 25% reduction in output of the Transport and Storage industry due to heavily reduced tourist travel. Retail Trade and Transport and Storage make up approximately 11% of the economy. As a third step we reduce the output of the rest of the economy (except the government sector) by 5% during the pandemic quarter and then by 10%. The impacts of these effects are shown over three time periods (3 months, one year and four years) in Table 1. All impacts are the percentage deviation of GDP from the baseline path of GDP without the pandemic shock. The impacts are shown as a percentage of annual GDP.

Table 1: Reduction in GDP from the baseline for different demand and industry closure scenarios

All cases have 40% infection rate, 2% case fatality rate, 40% absenteeism and average time off work of 3 weeks	Annualised reduction in first quarter real GDP	First year reduction in real GDP	Cumulative annualised 4 year impact
A: Sickness absenteeism and death only; no reduced demand or industry closure.	2.5%	5.9%	9.8% (3.2% due to death)
B: Output reduced by 75% for: Accommodation Restaurants and Bars, Cultural and Recreational Services, Personal and Other Community Services + 25% reduction for Retail Trade and Transport and Storage	3.6%	8.4%	12.9% (3.2% due to death)
C: B + 5% reduction in output for all other industries	4.0%	9.1%	13.9% (3.2% due to death)
D: B + 10% reduction in output for all other industries	4.5%	10.3%	15.3% (3.2% due to death)

The recovery path generated by NZTM for Case B is shown in Figure 2. This path is used to estimate the impacts beyond the quarter in which the pandemic hits New Zealand. The economy recovers much of the way back to full potential within the two years after the impact, where the level of full potential output is permanently reduced due to death. In terms of growth rates, economic growth is only negative during the pandemic quarter, growth is then above trend as the economy grows back to full potential.

Figure 2: Pandemic impact and recovery path (relative to baseline)



Clearly there is uncertainty surrounding the assumptions about the epidemiological features of a pandemic and therefore how it could impact on infection rates and workplace absenteeism. We therefore provide calculations showing how variations in these assumptions may affect the economic impact.

In the short term the reduction in output depends crucially on the rate of absenteeism and the average time people take off work. Increasing (reducing) the average number of weeks workers take off by one, while holding everything else constant, increases (reduces) the first year impact by around 1.5 percentage points (ppts). Increasing (decreasing) the infection rate by 10 percentage points to 50% (30%), increases (reduces) the first year impact by around 0.8ppts.

The death rate during the pandemic has its impact in the medium and long terms. Increasing (decreasing) the case fatality by 1ppt to 3% (1%) increases (decreases) the cumulative four year impact by approximately 1.7ppts. Table 2 shows the sensitivity analysis for our calculations as deviations from baseline in addition to those in Table 1. Using the values in Table 2, approximate impacts can be calculated for various cases around the ones we have presented in Table 1. For example the assumption that 15% percent of the workforce takes eight weeks off to look after children approximately doubles the reduction in labour supply during the pandemic. Table 2 can be used to evaluate the effect of removing this assumption; by reducing the level of absenteeism from 40% to 0% we reduce the first year impact by approximately 2.0 to 2.5ppts.

Table 2: Sensitivity analysis

	Annualised reduction in first quarter GDP	Annualised first year impact	Cumulative annualised 4 year impact
±1 week average time off	± 0.6 – 0.8ppt	± 1.2 – 1.7ppts	± 1.5 – 2.1ppts
±10ppt rate of absenteeism	± 0.2 – 0.3ppt	± 0.5 – 0.6ppt	± 0.7 – 0.8ppt
±10ppt rate of infection	± 0.3ppt	± 0.7 – 0.8ppt	± 1.5 – 1.6ppts
±1ppt case fatality rate	± 0.0ppt	± 0.3 – 0.4ppt	± 1.6 – 1.7ppts
±0.1ppt output reduction for each 1% labour supply reduction	± 0.3 – 0.4ppt	± 0.7 – 0.9ppt	± 0.9 – 1.1ppt

Qualifications and a Milder Pandemic

The impact of the severe scenario will be larger if the recovery takes longer. The speed of the recovery generated by NZTM is largely driven by increased investment due to low interest rates following the initial shock. It is possible that this response may not occur as strongly as in the NZTM model. Investment confidence may be weakened due to the pandemic itself, and the pandemic may also result in reductions in wealth if financial or housing markets were to falter. NZTM also assumes that demand from the rest of the world for our exports eventually returns to normal, which may not be the case. All of these effects potentially worsen the impact of a pandemic and could significantly lengthen the time required for the economy to recover.

On the other hand, because a pandemic is inherently a temporary shock, the economy may recovery much more quickly than we have assumed. Consumers may simply delay spending during a pandemic, meaning reduced economic output during the pandemic but a speedy recovery when the pandemic is over. The same may be true of investment decisions.

The NZTM recovery path assumes that at the onset of the pandemic the public debt target constraint is eased and public debt rises rapidly as the pandemic takes hold. It seems unlikely that a government would raise taxes during a pandemic to keep the debt level on target. However, a permanent increase in the debt level would be unsustainable and would be expected to have an adverse effect on the economy in the recovery phase or in the longer term.

The timeframe of the pandemic will also be crucial to the direct impact and the recovery. We have assumed that the pandemic shock occurs during one quarter only. There is potential for the shock to be felt over a much longer period, especially if a pandemic occurs in the rest of the world significantly before New Zealand, or if cases of pandemic influenza occur in New Zealand significantly before the major outbreak. In both these cases confidence of both businesses and consumers will be adversely affected before the pandemic takes hold. Multiple infection waves could also extend and accentuate the impact.

Higher levels of “social distancing” will lead to a larger short-term effect, but may reduce long-term impacts.

In our rough estimation of the initial shock to the economy we have included some effects of “social distancing”, where we expect industries that require a lot of social interaction will be badly hit. However we have not taken into account how this “social distancing” will affect the infection rates of the pandemic. Presumably the higher the level of “social distancing” that occurs in society, the lower the rate of infection and spread of disease. A lower level of infection will lead to a lower death rate and a smaller long term effect on the economy. At the same time, a higher level of “social distancing” will create a bigger initial shock to the economy. There is potentially a trade-off between the size of the initial shock and the long run effect. We have not investigated this here, instead assuming that the infection rate remains the same despite the extent to which industries close down and people adopt “social distancing”. The primary reason for this is that we have found little information about the effect “social distancing” would have on the gross infection rate.

The severe scenario we have presented above assumes that 80% of the workforce is away at some stage and for a considerable period of three weeks. In the event of a milder pandemic, where death rates are lower and mainly in the already ill or frail, the effect on the labour supply and on consumer demand could be much less. In a milder pandemic we could expect the level of absenteeism to be lower and that people would take a shorter time off work.

A pandemic with an infection rate of 30% and 0.25% case fatality would have a mortality rate of the same order of magnitude of the 1958 and 1967 pandemics. If we repeat the estimation above for a pandemic of this

magnitude with no additional absenteeism, and only one week of work off on average, the reduced labour supply would reduce GDP by 0.7% for the first year. If we include demand effects and industry close down rates a quarter of those used in cases B through D above, we estimate GDP would be reduced by 0.7 to 2.1% in the first year and after four years the cumulative reduction would be 1.1 to 2.8% of one year's GDP.

Other Large Shocks to New Zealand's Economy

To place the potential shock to New Zealand's economy from a pandemic in perspective we look at other shocks New Zealand has experienced.

Over the past 100 years, New Zealand has had 6 incidents (1909, 1922, 1931, 1932, 1949, 1952) where real annual GDP has dropped by 5% or more. The average annual growth rate over this period is about 3%. Hence, the probability of having an adverse shock that reduces annual GDP from baseline growth by 8% or more is about one in 20 years. It should be noted that these events all occurred near the first half of last century when institutional arrangements were significantly different than today. Since this time developed countries, New Zealand included, have tended to experience less fluctuation in aggregate output, suggesting that they have become more resilient to adverse shocks.

The most severe period of negative growth last century occurred during the depression in 1931, 1932 and 1933 when growth rates were -5%, -7%, and -0.25% respectively. If the potential real GDP growth rate over this period was 3%, this represents a drop from the baseline level of around 8% in the 1931, then 18% in 1932 and 22% in 1933. The level of annual GDP did not return to the 1930 *level* until 1936. Compared to the depression, our severe pandemic shock based on the Ministry of Health standard planning scenario has a similar first year impact, but a much smaller cumulative impact if we consider a four year period.

The Reserve Bank of New Zealand and the Treasury estimated the impact of a hypothetical outbreak of foot and mouth disease in the North Island (Gereben, Woolford and Black 2003). The initial shock to the economy generated by an outbreak was estimated to be 4% of quarterly GDP (1% annualised). This potential event was estimated to cause an annualised cumulative reduction in real GDP of around 3% over a two year period. This estimate of the impact of an outbreak of foot and mouth disease in the North Island is similar to our estimated impact of a milder pandemic.

Other Studies of the Economic Impacts of Pandemics

The economic impacts of potential influenza pandemics have been estimated in a number of studies using a range of methods. The scenarios investigated as well as the type of effects taken into account in each analysis vary widely. There are broadly two types of analysis used, the first looks at what society would pay to avoid a pandemic, usually in terms of how much is likely to be spent on health care, and how much will be lost from the economy in terms of lost work days and lost life. Examples include the papers by Meltzer *et al.* (1999) and by Balicer *et al.* (1999) which undertake cost benefit analyses of interventions including vaccination and use of antiviral drugs. The second type of analysis looks at the effect on GDP, typically taking into account the effect on labour supply and reductions in demand due to “social distancing” effects. The analysis contained in this paper falls within the second genre and for comparison purposes we briefly review recent similar studies undertaken for other countries, of which there are a growing number (see e.g. International Monetary Fund 2006)

Kennedy, Thomson and Vujanovic (2006) evaluate the channels a pandemic will affect the Australian economy by imposing a sequence of supply and demand shocks on the Australian Treasury macroeconomic model (TRYM). The pandemic they investigate assumes a population mortality of 0.2% and that 20% of the labour force is absent from work during the pandemic quarter. Kennedy *et al.* find that the most significant GDP reductions are due to confidence effects on household consumption and business investment, followed by the reduction in labour supply due to sickness and absenteeism. Over a year they estimate that Australian GDP would be around nine percent less than trend because of the pandemic. This result is towards the top of our range of estimates despite their lower assumed death rate. This is largely because of greater (in proportion to the death rate) confidence effects in the Australian analysis. Kennedy *et al.* believe that even “... with only a small number of deaths, the confidence effects on consumption are likely to be large and immediate and are likely to overshadow all other factors in the short-run.”

Sinclair and Blake of the University of Nottingham evaluate the potential impact of a pandemic on the UK’s GDP, although a full report of their work is yet to be produced (Nottingham University News Archive 2005). This study predicts an 8% GDP decline for a pandemic that directly affects 25% of the population, where affects means “contracting avian flu, having a family member infected, contracting another form of flu and being restricted from normal activities as a precaution, or being in an area of high incidence and being quarantined as a result.” Their potential pandemic has approximately 0.08% population mortality. The authors also modelled smaller impacts: the first being a contained local impact scenario that would see only a small number of deaths, and the second a SARS-like impact with widespread anxiety about catching the disease and people changing

their living and working habits to avoid unnecessary contact with other people. These scenarios cause respective 0.2% and 0.4% reductions in GDP.

Bloom, de Wit and Carangal-San Jose (2005) evaluate two scenarios for the Asian region based on a “relatively mild pandemic”, with an infection rate of 20% and a case fatality rate of 0.5%. The first scenario assumes a demand shock for two quarters followed by a milder demand shock in the following six quarters, and a supply shock due to sick workers being away for two weeks, with no additional absenteeism. The demand side shock reduces annual GDP growth in the Asian region by 2.3ppts and the supply side shock reduces growth by 0.3ppts. This aggregate Asian region reduction results from reductions in GDP that vary significantly for each Asian country, from 0.5ppts for Indonesia to 10.4ppts for Singapore, and depend on the openness of each economy and the size of the service export sector. The second scenario assumes that the psychological impact of the pandemic lasts longer and demand is seriously affected for four quarters with a milder demand shock in the following four quarters. In this second scenario the reduction in Asian annual GDP growth is 6.5ppts from the demand side and 0.3ppts from the supply side. The country specific reductions now range from 2.6ppts for Indonesian to 22.4ppts for Singapore.

The Congressional Budget Office (2005) has performed an evaluation of the impact on the United States’ GDP for two scenarios: a severe pandemic of 1918/1919 proportions and a mild pandemic of 1957 and 1968 proportions. The severe pandemic has a gross infection rate of 30% and a case fatality rate of 2.5%, whereas the mild pandemic has a gross infection rate of 20% and case fatality rate of 0.1%. In the severe pandemic there is a labour supply effect from those dying and people being away from work an average of three weeks, for which the CBO calculates a total GDP reduction of 3%. The CBO then looked at the demand side assuming for the severe pandemic an 80% reduction (for three months) in the entertainment, arts, recreation, lodging, and restaurant industries. Most other industries suffer a 10% reduction in demand except for the government and education sectors, which have no demand side effect, and health for which demand increases by 15%. Combining the demand side effects with the supply side effects gives the CBO a total 5% reduction in GDP. For the mild scenario the total effect is a decline in the level of GDP of 1.5%.

McKibbin and Sidorenko (2006) have provided one of the most comprehensive treatments of a pandemic’s potential macroeconomic consequences and provide a valuable benchmark for our estimates. They estimate the effects of four different scenarios on twenty economies, including New Zealand, that interact through trade and capital flows. McKibbin and Sidorenko explicitly attempt to evaluate the risk in investing in each country due to financial instability, health policy, government quality geographic location and international connectedness. New Zealand’s risk indicator is in the middle of the group, notably being higher than Australia, the United States, Europe and the UK.

The McKibbin and Sidorenko model calculates reductions in GDP for each country following from shocks to labour supply, demand for service sector output, to the financial risk, to costs of production and to demand. The results for New Zealand include a first year 1.4% GDP reduction in a 1968 type mild pandemic scenario, a 9.4% reduction for a severe 1918 type scenario and a 17.7% reduction for the even more severe “ultra” scenario. These results compare well with our own estimates. The main cause of reductions in GDP for New Zealand in the McKibbin and Sidorenko analysis is increased costs of doing business, followed by labour force reduction. The shock to the risk of investing in New Zealand has a minimal effect. In contrast to our results and the other studies, McKibbin and Sidorenko attribute a much smaller proportion of the reduction in GDP to reduced demand.

A significant result of the McKibbin and Sidorenko paper is that there could be a “flight to quality” of investment, where countries that have low financial risk could benefit from capital inflows. This highlights the importance of adequate preparation for a pandemic; if a country is seen to have prepared well and has a sound financial system, it may benefit from investment diverted from countries with higher risk.

These studies give a large range for the impacts of a pandemic on GDP. The difference in estimated reduction between our study and others is due to a number of differences in assumptions that highlight the uncertainties in modelling the economic effects of a pandemic. To begin with, the assumed characteristics of the pandemic are different in each study. Many of the studies assume death rates similar to that of the 1957 or 1968 pandemics, and all assume gross infection rates that are lower than assumed in the Ministry of Health standard planning model. Also the other studies have assumed little or no additional absenteeism, the exception being McKibbin and Sidorenko who assume absenteeism due to woman taking time off to care for children. This variation gives a different labour supply reduction in each study.

The judgements formed about demand side effects also vary between studies. Our demand side effects are broadly comparable with the CBO’s severe pandemic scenario. Another difference between our work and other studies comes in the treatment of the recovery. We have included a recovery path that approximately doubles the reduction in GDP in the first year. CBO in particular includes no recovery time and it is unclear how some other studies treat the recovery. For rough comparison, if we ignore the loss of output during the recovery and use parameter values roughly similar to the CBO, our result is a 4% reduction in GDP for the first year (CBO result is 5%). Including the recovery path increases the first year loss to 9%.

Conclusions

In May 2005 the World Health Organisation declared that the current outbreak of avian influenza is “the most serious known health threat the world is facing today.”¹² William Aldis, the World Health Organisation’s representative in Thailand, is reported to have commented in October 2005 that this outbreak of avian flu “is a threat to the poultry industry, but it’s not a big public health problem yet.”¹³ Clearly there is considerable uncertainty surrounding the potential for the current outbreak of avian flu to cause a pandemic. If a pandemic did occur, it could potentially impact severely on the New Zealand economy. This paper attempts to evaluate how a pandemic would affect New Zealand’s GDP and the potential size of that impact.

Using as a benchmark the Ministry of Health standard planning model, which in turn is based on the infection and mortality rates of the 1918 influenza pandemic, we estimate that the reduction in New Zealand’s annual real GDP in the year of the pandemic could be in the range of 5 to 10%. Over four years we estimate the loss will accumulate to around 10 to 15% of one year’s GDP. The range of estimates varies according to assumptions regarding the expected rate of absenteeism due to sickness and care-giving and to assumptions about the rate of reduction in consumer demand and temporary industry closure.

We also estimate that a pandemic with infection and case fatality rates similar to the 1958 and 1967 pandemics and with milder effects on the workforce and demand would reduce GDP by approximately 0.7 to 2.1% in the first year, an impact similar to a typical business cycle downturn. Taking into account a typical rate of recovery this would accumulate over four years to a loss ranging from 1.1 to 2.8% of one year’s GDP.

The necessity for “social distancing” is an important factor that is a significant source of the short-term loss of GDP growth. It is possible that as the rate of “social distancing” increases, and therefore the short-run adverse impact on GDP increases, the impact of a pandemic on infection and death rates would decrease thereby mitigating the adverse long-run effects. This possibility is not built into our analysis. Furthermore, we have not made any assessment of other potential policy responses to a pandemic shock such as, for example, the benefits of public investment in contracts to develop a vaccine that might reduce the potential extent of labour withdrawal and long-term impact on population and labour supply. Apart from the impact of a pandemic on population growth, we have also not incorporated any long-run effects that might arise for example from changes in labour productivity or from changes in international trading conditions. Just how these could change is uncertain.

¹² Statement by Dr Lee Jong-Wook, Director-General of the World Health Organisation to the 58th World Health Assembly, May 18, 2005.

¹³ Dominion Post, 1st November, 2005.

Our scenario results are based on several other important assumptions that are highlighted in the paper. In addition to the estimation of the initial supply and demand shocks, for which we provide a range of estimates, the estimated impact of a pandemic will depend on the appropriateness of the recovery path (which is based on past shocks and generated by NZTM), the duration of the pandemic, the coincidence between timing of the international and domestic pandemics, and the impact of a pandemic on asset prices and business finance.

What the results of this paper do suggest is that a severe pandemic has the potential to generate a significant loss of output and income growth. This suggests that policies that can encourage households, firms and financial institutions to undertake actions that will mitigate the risk of contagion and that can facilitate the economic recovery process warrant consideration.

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