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Macroeconomic Effect of Infectious Disease Outbreaks

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Introduction

Infectious disease outbreaks such as pandemic influenza or severe acute respiratory syndrome (SARS) in 2003 are, thankfully, rare events, but they do occur with some degree of regularity and impose a significant public health burden over a short period of time. For instance, there were three influenza pandemics in the twentieth century: in 1918, 1957, and 1968–69. Each was characterized by the rapid global spread of influenza. In the UK (and many other countries), there were three distinct waves of the 1918 pandemic, each lasting 10–15 weeks, with the largest occurring in the autumn of 1918. The 1957 pandemic occurred in the autumn of that year and comprised a single wave of approximately 15 weeks. The 1968–69 pandemic affected the UK somewhat later in the normal influenza season, resulting in a small first wave in March 1969 and a main wave in mid-winter of 1969–70. Clinical attack rates for the 1918 pandemic are thought to have been approximately 25%, and approximately 2.5% of those infected died. The 1957 and 1968–69 pandemics had higher clinical attack rates, (>30% and reaching 45% in some places), but with lower rates of mortality (case fatality ratio approximately 0.04%). The duration of illness is estimated at approximately 5–7 working days per case. In addition, the Swine Flu pandemic of 2009 was a reminder that pandemics seem to occur approximately every 30–40 years, but due to the mildness of the strain, greater population immunity, and the unusual timing of the pandemic there were fewer cases and deaths.

The structure of this article is as follows. First an overview of the link between outbreaks, productive labor supply, and economic effects is provided with reference to morbidity, mortality, and additional absenteeism. A brief discussion of healthcare expenditure related to outbreaks follows this before considering the more weighty issue of behavioral change in response to outbreaks. In the Section Health-Related Expenditure a discussion of the two main methods for macroeconomic assessment, retrospective analysis, and prospective modeling are discussed and selected results are presented and contrasted before conclusions are drawn.

Labor Supply Effects: Morbidity and Mortality

Without entering into a formal analysis of the effects of these outbreaks on productive labor supply, it is evident that, based on the observed 35% clinical attack rates for influenza pandemics, an additional period of absence in a given quarter year by one-third of an economy’s labor supply, will have a notable effect on its productive capacity. Simple economic theory teaches us that labor needs to be combined with capital and natural resources in order to produce goods. Although some degree of substitution of labor with capital may mitigate the impact of a reduction in labor supply, such substitution is unlikely to be able to counter the loss of, perhaps, 3–5% of an economy’s labor supply in a given quarter. Also, although the value of labor lost from the wage that is assigned to that specific quantity of labor can be estimated, this does not necessarily reflect the loss of productive capacity and the knock-on effects as the decline in one sector reduces the supply of intermediate goods to another and hence just-in-time deliveries are no longer able to meet their tight time targets. Although many of these economic effects are difficult to quantify, it should be evident that productive labor supply is just one element of the full economic cost of an outbreak. Clearly, the morbidity and mortality effects of an infectious disease outbreak vary greatly from perhaps 40 million worldwide deaths (aside from morbidity effects) from Spanish flu to 800 worldwide deaths from SARS. However, research suggests that the economic impacts of SARS were much greater than previous pandemics and much of this may be attributable to globalization and indirect health effects. Therefore, there is some evidence to suggest that direct health effects are not necessarily the only or even the main determinants of economic impact, even if they can be correctly estimated.

Labor Supply Effects: Additional Absenteeism

The loss of productive labor supply through illness and death is not the only factor which could reduce labor inputs to production. During school closure, government policies to mitigate an infectious disease outbreak may also be imposed. In extreme cases, these policies could include advising workers to avoid attending their place of work and, where possible, to work from home. However, a much more likely policy, (and one which the UK implemented in the mild swine flu pandemic in 2009), is a policy of either blanket or reactive school closure. Because children have lower immunity to influenza, mostly attributable to their lack of exposure to previous pandemics, higher clinical attack rates tend to be exhibited in schools than in the population at large. By closing schools, it is intended that the rate of infection amongst children will be reduced and thus will decrease or slow the burden of illness in the population.

However, the closure of schools, particularly primary schools, has an impact on working parents, some of whom may have to take leave from work in order to care for their children. Labor force estimates from the UK suggest that an average of 4.8% of working days will be lost in the quarter of the pandemic due to school closure that lasts 4 weeks, or 15%, if they close for the duration of the outbreak. Some of these estimates may be reduced when informal care arrangements and the ability of some parents to work from home are accounted for. However, the potential for a policy of school closures to result in a greater labor supply loss than the direct health-related effects is evident, and such costs occur in all sectors, not just health. As with the morbidity and mortality effects previously mentioned, these labor force losses will have
ripple effects throughout the economy, which need to be captured from the whole-economy perspective.

**Health-Related Expenditure**

In addition, many of those who are unwell and absent from work will not visit a hospital or primary-care facility, choosing rather to self-medicate, thus creating another health-related consumption change which may be hidden from healthcare sector expenditure. Some of this consumption may be captured by pharmacies in terms of increased purchase of, for example, pain medication and cold/flu remedies, but other purchases such as face masks and antibacterial hand gels will extend beyond the usual domain of treatment/prevention costs.

**Externalities: Behavioral Change**

Perhaps the largest potential contributor to the economic cost of infectious disease outbreaks is the externality of behavioral change. Many of the externalities which could potentially affect the economy as a result of an infectious disease outbreak are fear driven and difficult to predict, yet there is evidence to suggest that they do occur. Mention has already been made of the potential changes in shopping behavior which is linked to communicable disease, such as the purchase of self-medication, face masks, and alcohol gel, but more extreme changes in behavior may occur resulting in greater economic effects.

A survey was conducted in the follow up to SARS in eight countries (five European and three Asian), with a sample size of approximately 3500 individuals, to estimate the potential extent of precautionary behavior in order to avoid a pandemic. Although preferences elicited in this way may not reflect real behavior during an outbreak, conducting the survey shortly after the SARS outbreak may be of assistance in improving the validity of the theoretical responses in estimating true practice. The survey results suggest that 70–80% of Europeans would avoid using public transport, avoid entertainment events, and limit their shopping to the essentials. The percentages were similar but slightly smaller for Asian respondents, although Asian respondents were less likely to avoid entertainment events. In response to other questions, approximately one-quarter to one-half of respondents indicated that they would consider taking work absence, remove their children from school, limit social contact, avoid trips to the doctor, and remain indoors.

The evidence of whether such behavioral change is likely to take place in practice will shortly be examined. However, it is anticipated that a significant economic effect would result from any event imposing a substantial change in shopping patterns, attendance at work, and patterns of travel by the public at large, almost all of which would be manifested outside the health sector.

Several potential economic effects of communicable disease have been suggested which cannot be fully (or partly) captured from a partial equilibrium approach focused on the health sector and societal cost, which brings us to consider the evidence that such effects occur and present an alternative approach for their estimation.

**Macroeconomic Evidence**

In general, two approaches have been used: (1) retrospective estimation from economic statistics and (2) prospective macroeconomic modeling. Owing to their retrospective/prospective directionality, these provide complementary rather than competing evidence.

**Retrospective Estimation**

Using national economic statistics, it is possible to retrospectively estimate the impact of a significant economic event. Economic series are notoriously variable and therefore the isolation of an event’s impact assumes that all other factors remain relatively predictable or consistent. The analysis can take various forms, from a simple comparison of average statistics with those relating to an event of interest to more complicated statistical methods, and such analyses have been performed for infectious disease outbreaks.

The relatively few number of cases and deaths recorded during the SARS outbreak has already been mentioned. These low-level impacts on the productive labor supply would be expected to have little economic effect. However, the economic impacts of SARS have been estimated to be significant.

To capture the economic effect of the SARS outbreak retrospectively, a study was published in 2008 to estimate the economic impacts of SARS from national statistics. Results from that study suggest that Hong Kong suffered an approximate USD 3.7 billion loss to gross domestic product (GDP) and China’s GDP growth was reduced by approximately 3%. As less than 0.03% of Hong Kong and approximately 0.0004% of China’s population were infected with SARS, it seems unlikely that these economic impacts are greatly influenced by healthcare costs and losses of productive labor supply due to illness.

Further retrospective examination of sector-specific effects revealed losses to tourism-related sectors (hotels, restaurants, etc) for several countries amounting to, in particular, approximately USD 4.3 billion for Canada and USD 3.5 billion for China. In Canada, for example, there were declines in the output of the air transportation and accommodation industry of 14% between March and May 2003 and accommodation output fell by 8%.

These effects present compelling evidence that reasonably large-scale population behavior changes took place at the time of SARS. Some of this behavioral change may have been fear driven in order to avoid infection, and other changes may have been in response to the World Health Organization directive cautioning against travel to infected regions. It is also possible that some effects were attributable to an increased fear of travel at the time of the Gulf War, which highlights the potential uncertainties of retrospective macroeconomic analysis. The pros and cons of this approach are discussed in the following paragraph.

The advantage of retrospective macroeconomic estimation is that it is based on real data and is, therefore, not limited by assumptions as are modeling studies. However, there are three main limitations with this approach. The first, as has already been mentioned, is the confounding influence of other
significant sectoral or macroeconomic effects occurring at the time of the event being analyzed. The second is the limitation imposed by data availability. National statistics data can take time to reach the public domain, often in excess of 3 years, and this imposes considerable delays on effect estimation. Finally, and perhaps most obviously, such analysis cannot be used for prospective estimation and policy analysis, which brings us to consideration of an alternative tool.

**Prospective Macroeconomic Modeling**

Prospective modeling is very different from retrospective estimation. Macroeconomic models are usually based on real economic data and parameterized using either econometric estimation or calibration. Modeling scenarios are an essential element of macroeconomic modeling. These scenarios are designed to reflect the policy under analysis, including any investment required to accomplish an intervention or policy change, instruments (such as tax changes) to accomplish the policy goal, and, perhaps most importantly from our perspective, the health effects implemented through changes in labor supply to the economy.

Macroeconomic modeling is strong on the issues which are not well addressed by retrospective analysis. It is used for predictive purposes and is able to isolate the specific effects of the policy under analysis. Conversely, it is limited by the scenario design and, as with any modeling exercise, is limited by the validity of the assumptions underlying the scenarios and the model itself. However, most importantly, macroeconomic modeling is able to capture the wider whole-economy effects of communicable disease, particularly those properties of infectious disease outbreaks previously mentioned, which cannot be captured from the microeconomic perspective.

Several macroeconomic studies have been conducted to estimate the cost of infectious disease outbreaks. It is neither possible nor necessary to mention all these results in this brief article, but some results which highlight the importance of the macroeconomic approach to infectious disease impact evaluation will briefly be presented.

**Labor Supply Effects**

The computable general equilibrium (CGE) method is an important approach to macroeconomic modeling. It consists of a system of equations which specify the behavior of economic ‘agents’ in an economy and calibrates them on the basis of real economic data for a given country or region. For example, the agents include firms (who combine resource inputs to maximize profits), consumers (who consume and save to maximize their welfare), government, and foreign agents. Using this approach, it is possible to compare the economic impact of counterfactual (do nothing) scenarios with scenarios which reflect changes in health and policy. Several studies have designed scenarios which consider the labor supply effects of pandemic illness alone. In particular, the UK studies use two different models: the COMPACT model of the UK and the CGE approach. The models’ scenario designs differ slightly, but estimates of the GDP loss from labor supply reductions due to morbidity and mortality vary between approximately 0.2% for mild disease and up to 1% for severe disease. The scenario designs differ in their assumptions concerning school closure duration and the effect of that school closure in mitigating the outbreak, but all studies highlight that the economic impact of school closure alone is likely to impose equivalent or greater additional economic loss than the disease only effects.

**Behavioral Change Effects**

There may be many ways in which behavioral change can be mirrored using macroeconomic models. Two examples of this in published studies are work avoidance due to fear of infection relating to the labor supply and changes in consumption. In one article, prophylactic absence from work was modeled as an effect triggered in an individual by the knowledge that someone in their social network has died from the disease. The authors estimated the size of the average social network to be approximately 300 people, and by modeling disease scenarios of differing severity and interventions (vaccination) of differing efficacy, they were able to highlight the potentially much greater economic impact of a fear-induced response to avoid work compared with the disease only effect. The scenarios modeled showed that by avoiding a behavioral response to an outbreak, the potential value of interventions to prevent this harmful economic response might be greater than the value of the health effects alone, and had fear been the driver of behavioral change, the mortality rate of an outbreak might have a more significant effect than the number of people infected.

Changes in consumption based on the survey mentioned earlier have been captured in a macroeconomic modelling study. The modeling scenarios mirrored the postponement of purchasing luxury items: a 50% postponement of clothing purchases and an 80% postponement of goods and services. Some additional purchases were lost rather than postponed: 50% of car and service use and 30% of recreation and culture purchases. These consumption impacts contributed a first-year GDP loss increase of approximately 2% of GDP, which was 10 times the impact of mild disease alone. Although the degree to which this consumption change may take place is questionable, the ability to capture these macroeconomic effects and contrast them with the health effects demonstrates the strengths of macroeconomic modeling in the context of communicable disease.

**Accuracy of Macro Models**

As has been previously mentioned, the accuracy of macroeconomic models depends crucially on the modeling assumptions used. Furthermore, because macroeconomic models are designed for predictive purposes to isolate the economic effect of an event assuming all other things remain the same, it can be difficult to assess prospectively the validity of such models. However, immediately following the SARS outbreak, two macroeconomic modeling studies were published. One used the results of a CGE model designed to predict the impact of the SARS outbreak based on a 6-month
duration and capturing the changes to consumer demand and confidence in the future (investment implications). This model predicts a 2.63% GDP loss for Hong Kong and a 1.05% loss for China. The China loss, in particular, would be difficult to distinguish in such a rapidly growing economy, but the predicted GDP loss was approximately US$4.15 billion, which is similar to the approximate US$3.7 billion obtained by retrospective estimation from national statistics. Similarly, the other post-SARS study estimated the impact of SARS to vary, depending on its duration, to be between 0.2% and 0.5% for China, which would, again, be difficult to distinguish and which agrees with the retrospective study’s suggestion of ‘no evidence of a loss.’ The estimate for Hong Kong was between 1.8% and 4% or US$3–6.6 billion, which again contains the retrospective estimate. Although this is not proof of the accuracy of macroeconomic models, it provides some evidence of their usefulness in the context of communicable disease modeling.

Conclusion

Evidence suggests that the economic cost of communicable disease, particularly infectious disease outbreaks, is more than the sum of its direct health effects. Interactions between various sectors of the economy, and the processes of combining factors of production and the externalities associated with communicable disease, indicates that a whole economy, or a macroeconomic approach to economic analysis, is of great importance and is unlikely to equate to the ‘societal’ cost, which is estimated by scaling up microeconomic data. Therefore, although the detailed health sector or microeconomic approach remains very important for cost-effectiveness and cost-benefit analysis in general, it is important to remember that the health sector and its patients are inextricably linked to the wider economy and those wider economic effects must, therefore, be captured using appropriate tools such as macroeconomic analysis and modeling. By doing so, the wider implications of communicable disease and related policies can be assessed beyond the health sector at a population and economy-wide level.

See also: Infectious Disease Modeling, Macroeconomic Dynamics of Health: Lags and Variability in Mortality, Employment, and Spending, Macroeconomy and Health. Peer Effects in Health Behaviors. Health and Health Care, Macroeconomics of

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