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Protecting the Rural Poor: Evaluating Containment Measures Against Foot-and-Mouth Disease in Vietnam

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1. Introduction

Vietnam has achieved remarkable progress in reducing rural poverty in the last twenty years, largely due to a series of extensive market reforms in agricultural production and impressive increases in economic growth at the national level. As the result, the number of designated 'poor people' has been reduced by more than two-thirds (Hansen and Nguyen, 2006). As income increases, demand for livestock products is also growing rapidly. Per capita meat production per year in Vietnam increased from 25 kg in 2001 to 34 kg in 2005 (MARD, 2006b), and Vietnam aims at reaching per capita meat production of 36, 46 and 56 kg per person in 2010, 2015 and 2020, respectively (GOV, 2008). To meet the targets set out in the 'Strategy for Livestock Development' by the year 2020, the husbandry industry of Vietnam needs to develop an industrialized husbandry, free of diseases to meet domestic demand and potentially large increases in international exports. However, to expand its export market, Vietnam has to fulfil requirements under the SPS agreement, in particular, by establishing regions free of designated 'List A diseases', including foot and mouth disease (FMD).

Along with the desire to increase exports of agricultural products, protecting animal and plant health in Vietnam protects rural assets and ensures that the market reforms that have decreased rural poverty are not largely offset by potentially devastating losses in the economic value of cows, buffaloes and pigs. The rural poor, in particular, rely on these animals not only for

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sources of income and nutrition, but also (in the case of cows and buffaloes) for transportation and work in rice fields. Data compiled for this report estimate the asset value of cows and buffaloes alone in rural Vietnam is $4.9 billion USD (for 6 million cows and 3 million buffaloes, with an average value of $547 USD per animal).

This study evaluates the containment measures used in Vietnam against FMD. Foot and mouth disease is a highly contagious viral disease that causes significant mortality in young animals and considerable morbidity in adults, with large losses in weight and economic value. In particular, this study conducts a cost-benefit analysis of a recent and aggressive vaccination program used in Vietnam against FMD. Programs of this sort are fundamental to protecting rural asset values and the livelihood of the rural poor.

Section 2 of the report describes FMD in Vietnam and its control measures. Section 3, the main part of the report, conducts the cost-benefit analysis on the vaccination program used in Vietnam to control and potentially eradicate FMD. Section 4 provides closing remarks and recommendations.

2. Foot and mouth disease status and its control in Vietnam

Foot and mouth disease is a highly contagious viral disease that causes significant mortality in young animals and considerable morbidity in adults, with large losses in weight and economic value. FMD is characterized by fever and blister-like sores on the tongue and lips, in the mouth, and on the teats and between the hooves. While the majority of affected animals recover, the disease often leaves them weakened and debilitated. The FMD virus can be found in all secretions and excretions from acutely infected animals, including expired air, saliva, milk, urine, faeces and semen. Transmission can occur by direct or indirect contact with infected animals and contaminated surfaces, and is commonly spread through the inhalation of the aerosolized virus, ingestion of contaminated feed, and entry of the virus through skin abrasions or mucous membranes (Aftosa, 2007).

FMD appeared very early in Vietnam (the first case reported in 1898) and has been in existence for more than a millennium at various scales. Since the extensive market reforms have taken place, the transportation of animals and animal products inside the country and the cross borders with China and Cambodia has resulted in an increase in the trend and quantity of infected animals, as well as an increase in the number of species being affected (including deer and goats). Three types of FMD viruses are in Vietnam. Virus type-O has been defined as the main strain since 1995, presumably as part of a pan-Asian epidemic. Virus type-A ('Malaysia 97') was discovered in 2004 due to the smuggling of cows from Cambodia. In 2005, virus type-Asia 1 was discovered from illegal animal smuggling from China (MARD 2008). Prior to the initiation of the vaccination program in Vietnam, in early 2006, the number of new infections each year among cows, buffaloes and pigs is given in Table 1, for the period 1999-2005. New outbreaks in 1999 and 2000 were dramatically high, but there are significant increases in the number of new infections in each year leading up to the beginning of the vaccination program.

Table 1: FMD incursions, infections and dead or culled for cows, buffaloes and pigs in Vietnam, 1999 to 2005.

Year	Buffalos / Cows					Pigs				
	FMD Provinces	FMD districts	Incursions	Infected	Dead or culled	FMD Provinces	FMD districts	Incursions	Infected	Dead or culled
1999	55	347	1,912	112,579	1,309	52	217	958	25,820	3,270
2000	48	126	1,708	351,284	15,136	51	266	1,148	42,999	14,986
2001	16	29	47	3,976	112	17	47	95	6,428	1,534
2002	26	71	183	10,287	194	28	75	208	6,933	2,229
2003	28	88	266	20,303	116	28	67	123	3,533	712
2004	32	134	490	25,658	189	22	35	87	1,555	725
2005	26	160	408	28,241	582	25	-	-	3,976	1024

Source: MARD, 2008.

There are many challenges in the fight against FMD. The first challenge is how to quarantine and control the transportation of animals within the country and across borders. As Vietnam has a long border with difficult geographical conditions, contiguous to countries that are endemic with FMD, in particular, China, Cambodia and Laos, it is difficult to prevent illegal trans-border trade of cattle. Second, domestic quarantine is less than perfect, due to a lack of local veterinary services with sufficient equipment and resources. Cooperation between the animal health agencies with relevant agencies such as the police, the military, and market management agencies is also not sufficient. Third, the level of awareness of various diseases, although growing rapidly thanks to education campaigns, is very low among the rural population and the Ordinance of Animal Health and along with comparable regulations on the prevention and transmission of FMD is not always and everywhere followed, making the containment of FMD in Vietnam a significant battle.

With increasing trans-border trade, fighting FMD inside the country alone is obviously not sufficient. Vietnam has actively been cooperating with other countries in the region to eradicate FMD. In addition, Vietnam has been a member of the World Organization for Animal Health (OIE) since 1991, and actively participates in the 'South-East Asia Foot and Mouth Disease Campaign 2020' (SEAFMD 2020), and with it, the Lower Mekong and Upper Mekong working groups under SEAFMD since 1997, all committed to combating FMD in the region. Vietnam has also received technical and financial support from many international organizations and countries in its effort to gain recognition of 'FMD free status' at least in some regions and localities in Vietnam.

Over the last decade, Vietnam has taken aggressive measures to combat FMD. In 2001, Vietnam launched the 'National Framework Plan' for FMD control 2001-2004, as part of

Vietnam's effort to integrate into regional efforts to contain and eradicate FMD. With the assistance from the OIE, and its own limited resources, the Plan aimed at establishing a sound legal framework on FMD prevention and protection, training veterinary staff, increasing the awareness of epidemiological characteristics and the economic impact of FMD, which all laid a solid foundation for developing a national plan on FMD containment and eradication in the following years.

Benefiting from the National Framework Plan, Vietnam has established a sound legal framework in FMD prevention and protection with the issuance of Decision No. 54/2001/QD/BNN-TY, dated 11 May 2001, which was later replaced by the Decision No.38/2006/QĐ/BNN-TY, on 16th May 2006, on regulations regarding the prevention and control of FMD in animals, and Document No.444/HD/TY on 14th August 2001, which was later replaced by Document No.752/TY- DT on 16 June 2006, to guide the implementation of these regulations. In addition, a host of documents instructing the Provincial People's Committees and relevant ministries and agencies has been issued to engage in epidemic prevention and control.

Public awareness campaigns have also been extensive: 70 training courses have been held nation-wide on techniques of prevention and control of FMD and veterinary epidemiology for 6,000 participants from provincial and district veterinary departments and stations, and 1,443,000 leaflets, 82,648 posters, 15,000 handbooks on prevention and control of FMD have been issued. A video tape on FMD on animals and prevention method has been developed and has aired repeatedly on national and local television stations. Thanks to these activities, public awareness of FMD has improved significantly. In addition, Ministry of Science and Technology has assigned the Department of Animal Health with the VND1.8 billion project 'Research on epidemiological solutions for detection and control of foot and mouth disease in livestock' (MARD, 2005).

Following a serious FMD incursion and spread in 1999, causing serious damage to the livestock industry, the central Government in 2000 allocated 15 billion VND (equivalent to about 1 million USD) to support the purchase of vaccines in provinces and cities for the control of the disease. In 2001, 2002 and 2003, the central Government allocated on average VND 2-3 billion from national reserves to support the control of FMD in heavily affected provinces with budget constraints. Between 2001 and 2003, the Ministry of Finance and MARD have also received 4.7 billion VND as allocations to the Department of Animal Health for the prevention and control of FMD. At the provincial level, since 1999, on average each province has spent roughly VND 50-100 million per year on the purchase of vaccines and disinfecting chemicals, as well as supporting farmers whose animals are culled (MARD, 2008).

After five years of preparation, a major new initiative was launched in 2006. The Government of Vietnam established a comprehensive national program, costing 538,856 million VND (equivalent to about 34 million USD) for the containment and eradication of FMD over the five year period 2006-2010 (MARD, 2008). In practical terms, Vietnam follows a progressive zoning, which is based on the epidemiological data from 1994-2004, recommendations of the OIE and geographical conditions, livestock raising practices and other socio-economic factors and the FMD containment objectives (MARD, 2005).

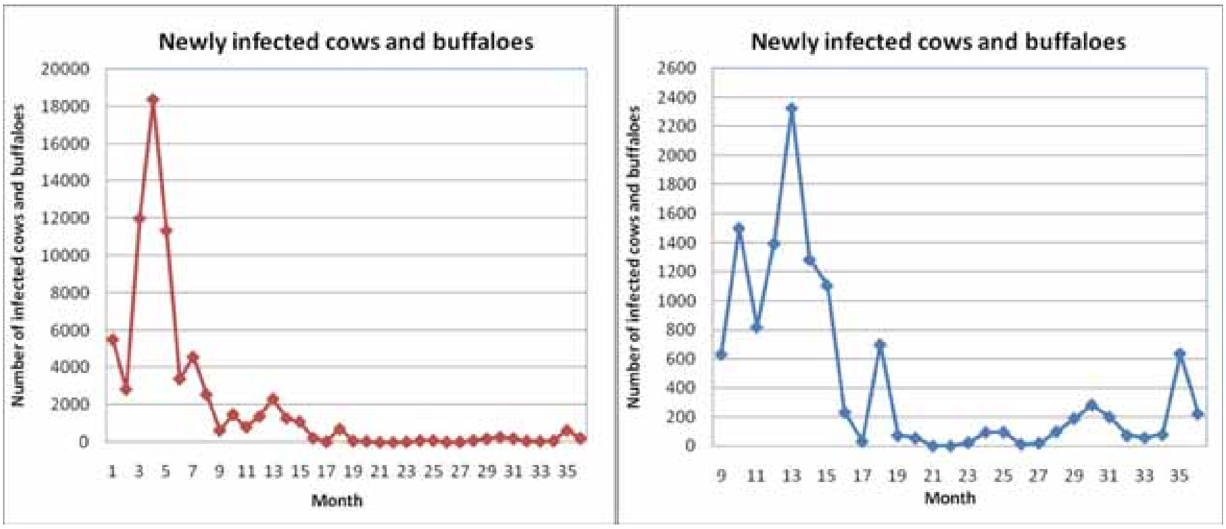
Three zones (see Van et al. 2008 for maps with more details) with different strategies to handle FMD are established in Vietnam as follows:

- A control zone, which covers 19 border provinces and 22 border districts, has periodical vaccinations twice a year on 100 per cent of livestock for 2 years since the year of the outbreak. The scope and rate of the follow-up vaccination is to be defined after completion of the first 2-year period, depending on the actual situation.
- A buffer zone includes 18 provinces adjacent to the control zone with high risks of FMD outbreak. Periodical vaccination of 80 per cent of high-risk livestock, designed as the livestock in the areas with outbreaks in the past, along control on movement along main roads and through animal markets.
- A Temporarily free zone covers 27 provinces, with 10 provinces in the Red River Delta, 4 provinces in the focal exporting area (Nghệ An, Thanh Hoá, Phú Thọ, Vĩnh Phúc), 9 southwest provinces and 4 Southeast provinces. No vaccination is conducted in these areas, except for ring vaccination in case of a widespread outbreak.

Along the lines with the vaccination program, disease surveillance is carried in an active manner by improving the veterinary system from central to local levels, assisting with early detection of the disease and identifying the virus type and sub-type by doing blood tests. In control zones, the sample size of the blood survey is based on the herd size of susceptible livestock and other disease factors. In the buffer zone, the sample size of the blood survey is based on the herd size of the susceptible livestock in past outbreaks and designation of 'high risk' zone (i.e., villages surrounding livestock trading markets and slaughter houses; communes acting as intermediate points along the trading path areas for livestock; towns passed by national highways, and so). In temporarily free zones, the disease on buffaloes and cows is investigated using 3ABC ELISA tests, with a sample size of 10-20 cows or buffaloes for each commune, depending on herd size. Totally, there are 5,260 samples collected each year of which 4,700 sample are used for blood tests, 500 for virus examinations and 60 samples for virus separation.

After three years of program implementation, Vietnam has made substantial progress in containing FMD with the number of outbreaks and newly infected animals declining dramatically. In the year 2006, the total newly infected animals (including buffaloes, cows and pigs) numbered 95,000 heads, identifiable in 52 out of 64 provinces. In the year 2008, this number has reduced to roughly 2000 heads in 10 provinces. Figure 2 shows data for the number of newly infected animals in Vietnam. The vaccination program is thought to have its key impact (given two inoculations in 2006) in September 2006. The left-hand panel in Figure 1 shows newly infected cows and buffaloes since January 2006. The right-hand panel shows newly infected animals since September 2006. The decrease in the mean and variance of newly infected animals is dramatic.

Figure 1: The effect of vaccination on newly infected animals.
Left-hand panel is newly infected animals from January 2006, by month;
the right-hand panel is newly infected since September 2006.



Source: MARD, Department of Animal Health, 2009.

It is important to note, however, that vaccination doses are not evenly distributed among species (see Table 2). Only about 3 percent of pigs are vaccinated compared with more than 40 per cent of buffaloes and cows. There are a number of reasons for this. First, the economic life span of pigs is relatively short, about 6 to 8 months compared with 12-24 months for cows and, in some cases, even up to 10 to 15 years for cows and buffaloes if these animals remain with farmers for many years to help on farm and in rice fields. Therefore, for pigs, it is deemed more economic to slaughter if infected, rather than to vaccinate. In addition, as the life span of a cow or buffalo is longer, the FMD virus will stay longer in the environment with these animals, thus increasing the risk of further infection. Second, vaccination is more effective in cows and buffaloes than in pigs (with effectiveness rates of 80 versus 50%). Third, it is often the case that the FMD is transmitted from cows or buffaloes to pigs, and far less likely in the opposite direction. Hence, increasing the immune system and concentrating on FMD in cows and buffaloes is more likely to help control FMD in pigs.

Table 2: Vaccination rates by species for the years 2006-2008

Year	Buffalo/cow				Pig			
	Herd size	Infected	Vaccinated heads	Vaccination rate	Herd size	Infected	Vaccinated heads	Vaccination rate
2006	9,431,845	64,888	4,032,530	43%	26,855,330	28,483	739,386	3%
2007	9,721,118	5,916	4,032,530	41%	26,560,651	5,539	739,386	3%
2008	9,235,480	1,369	4,032,530	44%	26,701,598	23	739,386	3%

Source: Own calculation based on the data from GSO (2007), GSO (2008) and MARD (2008)

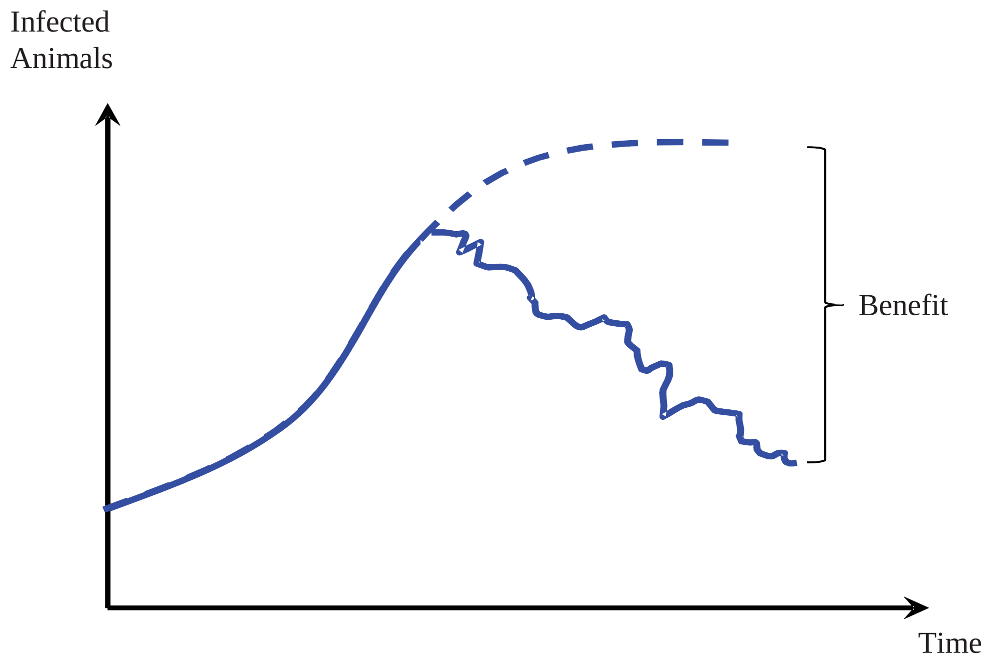
3. Cost Benefit Analysis of the National Strategy on Containment and Eradication of Foot and Mouth Disease

Of particular interest in this report is the recent aggressive vaccination campaign and its cost effectiveness. To carry out an economic assessment on the 'National Strategy on Containment and Eradication of Foot and Mouth Disease', initiated in 2006, we do a cost benefit analysis of this strategy. We focus only on the cost benefit analysis of vaccination for buffaloes and cows as the vaccination rate of these species is more than 40 per cent. This vaccination rate in reality may be much higher as information on the vaccination paid privately by farm households and enterprises is not available.

3.1 The cost-benefit analysis (CBA) strategy

The cost benefit analysis requires a combination of epidemiological and economic modelling. The epidemiologic modelling is used to simulate the FMD spread assuming there was no vaccination program in place. Using this information, together with information on vaccination costs and the value of damages that result from the disease provides all of the necessary information for the construction of net present values and benefit-cost ratios. To fix ideas, consider Figure 2. The solid and smooth line (which at one point becomes dotted) represents a logistic growth pattern for the spread of FMD in an environment. (Actual growth and spread rate models are usually much more complicated, of course, and often combine area and density measures.) The vaccination program is assumed to begin at the point where the dotted line begins, with hypothetical immediate impacts, with random fluctuation, resulting in falls in the number of infected animals (as new disease-free replacements take the place of cows with FMD that are killed or sold for meat products in the market).

Figure 2: The spread of infected FMD animals and a containment and eradication action



The benefit of the vaccination program in this diagram is measured as the difference (at any time *t*, but typically at full saturation of the population without vaccination) in the number of infected animals without the vaccination program (i.e., the dotted line), and the actual number of infected animals with the vaccination program in place. The benefit is thus the value of the avoided losses due to FMD with vaccination, given that there are fewer FMD animals. A more aggressive vaccination program may clearly result in larger net benefits, depending on the relative cost of the vaccination program, compared to the benefits or the value of the avoided losses. The precise measure of net benefits can also be calculated as the difference between the numbers of infected cows without vaccination, compared to those with vaccination, at each point in time until saturation of the population. This measure of cows, once again, has to be valued and compared relative to the cost of the vaccination program.

In our CBA we follow ten basic principles, given by:

1. The measure of benefits is given by all known avoided losses (e.g., losses to plant, animal and human health; damages to the environment, losses from trade bans, spillover effects and social costs, etc.).
2. The measure of benefits is conditional on an area and density spread model and specific actions taken (and their likely effects).
3. The measure of cost is the cost of all specific containment or eradication actions (e.g., sprays, vaccinations, screening, inspections, blood tests, public awareness, etc.).
4. Prices and costs may vary over time (e.g., marginal losses tend to rise over time for environmental assets; depending on price elasticity, an FMD incursion can increase the price of beef over time).

5. Where dollar amounts of costs and benefits cannot be measured by market values, non-market valuation methods must be used (e.g., contingent value, hedonic pricing or choice modelling exercises).

6. Since streams of costs and benefits vary over time, and potentially occur at different points in time, all dollar amounts must be discounted to the present.

7. The discount rate is typically the 'Treasury Bill' or 'Bank Rate' (i.e., the common or 'non-risk adjusted' rate).

8. The time horizon for discounting is normally contingent on the time taken for full biological or spatial (area and density) saturation. (With discounting, dollar values may be close to zero before this time, and/or the marginal cost of ongoing containment may equal the marginal benefit well before saturation, and/or across different containment measures; or additional net present value benefits may become negative. Comparing containment measures across various incursions with different duration or with varying time horizons may require 'Annual Equivalent Cost Methods'.)

9. Measures of net present value and/or the benefit-cost ratio should reflect likely outcomes, based on given or estimated probability distributions of key parameter values (e.g., Monte Carlo draws based on a probability distribution, for example, for spread rates, or the variance in market values, gives a range of benefit-cost ratios with assigned likelihoods).

10. Sensitivity analysis on parameter values (to determine their relative importance) should be reported and, where possible, estimates of net present values or cost-benefit ratios with different 'states of nature' should be constructed.

3.2 Epidemiological modelling

As mentioned, our CBA needs to compare the difference in the number of FMD infected buffaloes and cows with and without vaccination program. Under the scenario of not having vaccination, and assuming a monthly time step, the growth in the number of infected buffaloes and cows is assumed to follow a Verhulst-Pearl logistic function, or:

$$\frac{dN(t)}{dt} = rN(t)\left(1 - \frac{N(t)}{N_{\max}}\right) \tag{1}$$

for $N(t)$ is the number of infected buffaloes and cows at time t, r the biological growth rate and N_{max} the maximum number of potentially infected buffaloes and cows in the population. Data on infected buffaloes and cows for the first eight months of 2006 is used as the benchmark for simulating the FMD situation when there is no vaccination, with August 2008 as the cut-off point for the beginning of the vaccination-affected period. There are a couple of reasons to justify this choice. First, the month of starting the vaccination program was specified as March-April in Vietnam but it was not actually implemented until May, June or even as late as July in some areas as there was supply shortages, transportation and other bureaucratic delays. Second, as most animals were first time vaccinated, the vaccination could take effect only after the second shot, four weeks later.

To estimate equation (1) we approximate the left-hand side of this equation by

$$\frac{1}{N}\frac{dN}{dt} \approx \frac{N_{i+1} - N_i}{1/2(N_{i+1} - N_i)} = 2\frac{N_{i+1} - N_i}{(N_{i+1} - N_i)(t_{i+1} - t_i)} \tag{2}$$

and regress

$$\left\{\frac{N_{i+1} + N_i}{2}, 2\frac{N_{i+1} - N_i}{(N_{i+1} - N_i)(t_{i+1} - t_i)}\right\}_{i=1}^{\cdot N} \tag{3}$$

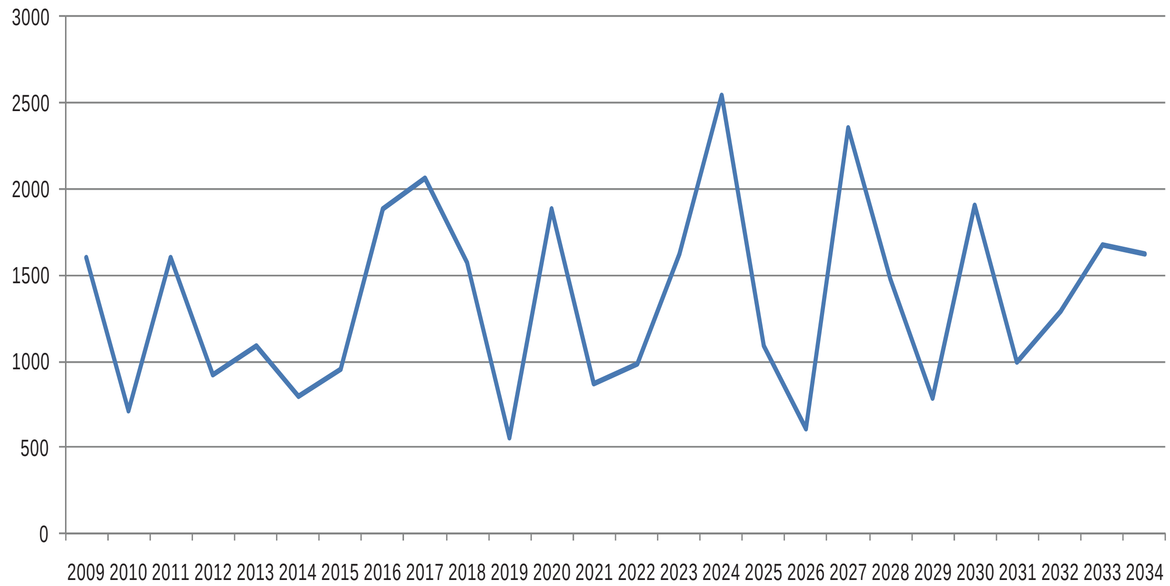
on

$$r - \frac{r}{N_{\max}}N \tag{4}$$

to estimate *r*. Since FMD can spread easily, and especially so in a country like Vietnam, we assume that $N_{\max}$ is simply the size of the total population of cows and buffaloes in Vietnam, or roughly 9 million head. By this procedure, the estimated monthly value of *r* is .0263 with a standard error of .0048 and a *p-value* of .003. The standard error is used to generate randomness in the pattern of FMD spread in the CBA analysis.

The CBA must be calculated over a forward period, potentially as long as the time it takes to reach full saturation of the population without vaccination or $N_{\max}$. To do so we need an assumption about the number of newly infected animals with vaccination, beyond the sample months detailed in Figure 1. To be conservative, we assume that newly infected animals in the future follow the same pattern as given in the right-hand side of Figure 1, from month 18, or the series in the actual data from the last 17 months (i.e., from July 2007 till December 2008). To mimic a future pattern along these lines we simulate by assuming random draws with from a stratified Monte Carlo exercise with the mean and variance set by the actual data in Figure 1. The reason this is a conservative procedure, of course, is that one would expect (and certainly hope) that the vaccination program should decrease the mean and variance of the number of infected animals over time. Data from 2009 and 2010, when it is available will help determine whether this is the case. An example realization of this process, for an average of ten thousand different realizations is given by year in Figure 3.

Figure 3: Random process of newly infected animals given by a stratified Monte Carlo draw, aggregated to years, from months, under the vaccination program



This now allows us now to compare the number of infected animals both with and without the vaccination program.

3.3 Economic benefits and costs

The economic benefit of the vaccination program is given by difference in the economic value of the cows and buffaloes that would have been infected without the program. The benefits are comprised of four key items: (a) the value of culled and/or dead cows and buffaloes; (b) the value and weight loss of cows and buffaloes due to being FMD infected; (c) any milk loss due to infected cows; and (d) any other expenses associated with an outbreak. We ignore any effect on the price of meat in local and national markets, since this data is not readily available. Some of the key parameter values are listed in Table 3 below. Construction of these parameters is detailed as follows:

Average weight of a cow and/or buffalo: The average weight of a cow and/or buffalo is assumed to be 250 kg. This is the average weight of 175 buffaloes and cows culled due to being FMD infected in 2008 in the province of Nghe An, where a major FMD outbreak occurred, and is also based on reports by the Department of Husbandry, indicating that the average cow weight is roughly 200 kg, while the average buffalo weighs more than 300 kg (MARD, 2006b and MARD, 2006c). *Unit price of live cows and buffaloes per kg*: This value is given as VND 35,000 per kg (equivalent to 2.19 per kg USD using the exchange rate of 16,000 VND/USD) for the year 2008. This also roughly corresponds to the compensation rate provided by the Government of Vietnam for culled cows and buffaloes with FMD, currently at 30,000 VND, which was deemed to be as much as 70 per cent of market price. *Unit price of fresh milk*: The farm gate price for fresh milk is 7,000 VND, 6,000 VND and 5,000 VND per litre in 2008, 2007 and 2006 respectively. *Weight and value loss (as a percentage) due to being FMD infected*: When a cow or buffalo is recognized as FMD infected, it is reluctant to eat, which leads to rapid weight loss. The Department of Animal Health is Vietnam estimates the average weight loss over the economic life span of the animal to be 25 per cent (MARD 2008). We assume a normal probability distribution of *N~(1,0.05)* for this parameter.

Compulsory culling and natural death rate: Although it is reported that the overall mortality rate in cattle is less than 5 per cent and 50 per cent of the calves may die from myocardial degeneration (Fowler and Mikota, 2006), the data on dead and culling livestock in Vietnam from 2006-2008 indicates a rate of 2 percent for mortality and culling. *Dairy*: The ratio of dairy in the total infected herd is obtained by using the same ratio of the ratio of dairy in the total herd in Vietnam in years from 2006 till 2008 (GSO 2007 and GSO 2008). The milk produced per dairy per year for 2006-2008 is obtained from the GSO (2007) and GSO (2008). In many cases, FMD can result in a permanent loss in milk production. We assume a 50 per cent reduction in milk production based on established studies in MARD (2008). A normal distribution for this parameter value is assumed, with a standard error of .05. Finally, the *unit cost of other expenses* such as petrol, checkpoint, and staff duty allowances per animal is the average of spending level per cow and buffalo drawn from 18 outbreaks in 10 different provinces in 2008 (Van, 2009).

Table 3: Key parameter values for the measures of the benefits from vaccination against FMD in Vietnam, for years 2006 to 2008

	2006	2007	2008
Cattle unit price per kg (USD)	1.62	1.82	2.19
Milk price (farm gate) per litre (USD)	0.31	0.38	0.44
Weight and value loss due to FMD infected animal (%)	25% N(1,0.05)	25% N(1,0.05)	25% N(1,0.05)
Weight per cow/buffalo (kg)	250	250	250
Compulsory culled percentage (%)	2%	2%	2%
Ratio of dairy in the total herd (%)	0.63%	0.63%	0.70%
Milk produced per dairy cow (litre/year)	3,816	3,816	4,027
Loss in milk production due to FMD infected animal (%)	50% N(1,0.05)	50% N(1,0.05)	50% N(1,0.05)
Meat production (tonnes)	224,746	273,651	298,739

The cost of the vaccination program was obtained from actual expenditures on the national program, for the years 2006-08, and projected expenditures for the years 2009 and 2010 (MARD (2008) and Van (2009)). Table 5 summarizes the key information. There are a number of different categories of expenditures, for example, the development of epidemiology maps, and blood tests and virus studies. The main cost, however, is the cost of vaccination. In Table 5 the Dong to USD rate is 16,000:1. The total cost of vaccination in 2008, for example, is 10.7 million USD, and is projected to be 11.1 million in 2009. Contingency funds are used to handle outbreaks of FMD. Values of this category for 2006 to 2008 are actual expenditures, assumed to remain constant per year in 2009 and 2010. The total cost of the vaccination and containment program from 2006 to 2010 is 47.3 million USD.

The discount rate used in the CBA is 5 per cent, or the current State Bank of Vietnam discount rate promulgated in the State Bank of Vietnam's Decision No. 837/QĐ-NHNN dated April 10, 2009. All costs and benefits are forward projected based on estimates of changes in the consumer price index. The resulting inflation rate is assumed to take a mean of 7 per cent, with a standard deviation of 6 per cent. For the most part, assumed changes in the average price level affect both the stream of costs and benefits in a comparable manner. Sensitivity measures are reported for the rate of discount.

Table 5: Total costs of the vaccination program, actual and projected from 2006 to 2010, measured in USD

	2006	2007	2008	2009	2010
Management expenses	16,313	40,625	55,625	55,625	55,625
Training			34,188	34,188	34,125
Awareness campaign	69,688	69,688	104,500	104,500	104,500
International conference			4,375	4,375	4,375
Domestic conference			1,250	1,250	1,313
Outbreak reporting			8,375	8,438	8,438
Sending sample abroad for virus type separation			2,250	2,250	2,250
Research on causes of FMD			20,000		
Development of epidemiology map			2,750	2,750	2,750
Blood test analysis and virus study	7,500	18,750	123,125	123,188	123,188
Sterilization chemical	15,000	15,000	118,125	118,125	118,125
Labour cost for vaccination	1,093,750	1,093,750	1,100,500	1,100,500	1,100,500
Control zone vaccine for buffaloes and cows	1,789,992	2,563,130	2,416,376	2,668,688	2,668,688
Buffer zone vaccine for buffaloes and cows	2,986,853	1,523,375	2,715,037	2,852,750	2,852,750
Contingency fund(*)	1,158,323	1,193,384	4,041,523	4,041,523	4,041,523
Vaccine under Decision 738 for buffalos & cows	190,646	504,225			
Total Cost	**7,328,064**	**7,021,926**	**10,747,998**	**11,118,148**	**11,118,148**

Source: MARD (2008)

(*): Data compiled from various decisions issued by MARD in 2006-2008 on the use of the Contingency Fund and vaccine allocation in accordance with Decision No. 738/QD – TTg dated 18/5/20006

3.4 CBA results

Since we have assumed that the containment action corresponding to the vaccination program continues at both the same cost and the same pattern of newly infected animals over time, the measure of net present value (NPV) and the benefit-cost ratio (BCR) will partly depend on the choice of the planning horizon. In cases where a containment action leads to eventual eradication or very small amounts of newly infected animals, with consequently small ongoing vaccination costs, both NPV and the BCR would be maximized at the point where the entire population of infected animals, without the vaccination program, would be infected, or at full saturation. With significant and ongoing containment costs this is not the case. Given the logistic spread growth pattern, at some point the extra costs associated with vaccination may be outweighed by the benefits of having less newly infected animals. Of course, realism suggests that the vaccination program should eventually decrease the mean and variance of newly infected animals, and the cost of the vaccination program should clearly decrease over time as the need for vaccination falls with the proportion of the herd now immune or vaccinated against FMD.

Table 6 presents the main CBA results. The base discount rate is 5%. The sensitivity of the discount rate is then tested using the discount rate over the range of 5-7%. Given the spread model, the year 2040 is the time horizon where the population is FMD saturated in the absence of a vaccination program. Year 2033 is the time horizon in which the net present value is maximized. After the year 2033, on average, the net present value of benefits starts to fall, given that the marginal cost of the vaccination program (again, assuming the same pattern of newly infected animals) in year 2034 exceeds the marginal benefits. This property is shown in Figure 4. The NPV in both 2033 and 2040 is substantial, ranging from 1.16 to 1.22 billion USD. We take 2033 as the base case. Given uncertainty in the spread rate, the loss is weight and value of an FMD infected animal and the loss in milk production, the resulting BCR and NPV measures have a standard error, as reported in Table 6. As such, Figure 5 shows the relative frequency distribution for NPV for the year 2033 with a 5% discount rate, and Figure 6 illustrates the relative frequency distribution for the BCR.

Table 6: Main CBA results: measures of the benefit-cost ratio and net present values by discount rate and time horizon. Standard errors are in brackets

Discount Rate %	Benefit-Cost Ratio		Time Horizon 2033 (million USD)			Time Horizon 2040 (million USD)		
	Time Horizon 2033	Time Horizon 2040	Net Present Value	Net Present Benefit	Net Present Cost	Net Present Value	Net Present Benefit	Net Present Cost
0.05	5.26	4.06	1,220	1,513	294	1,163	1,558	395
	[1.25]	[1.04]	[285]	[282]	[43]	[300]	[292]	[70]
0.06	5.17	4.13	1,033	1,286	254	991	1,320	329
	[1.2]	[1.03]	[239]	[237]	[36]	[250]	[244]	[55]
0.07	5.06	4.17	877	1,097	221	846	1,122	276
	[1.14]	[1.01]	[202]	[200]	[30]	[210]	[205]	[44]

Figure 4: Net present values of the vaccination program at a 5% discount rate, 2006 to 2040

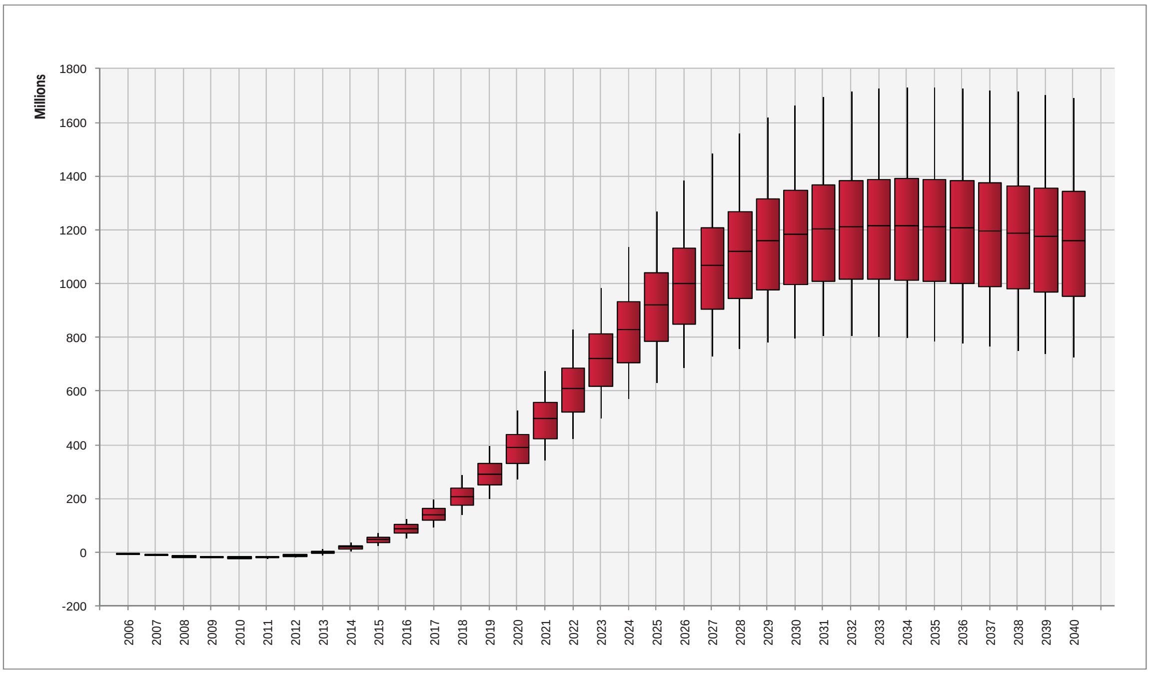


Figure 5: The relative frequency distribution for NPV for the time horizon 2033 with a 5% discount rate. Mean is 1.22 billion USD with a standard error of 285 million USD

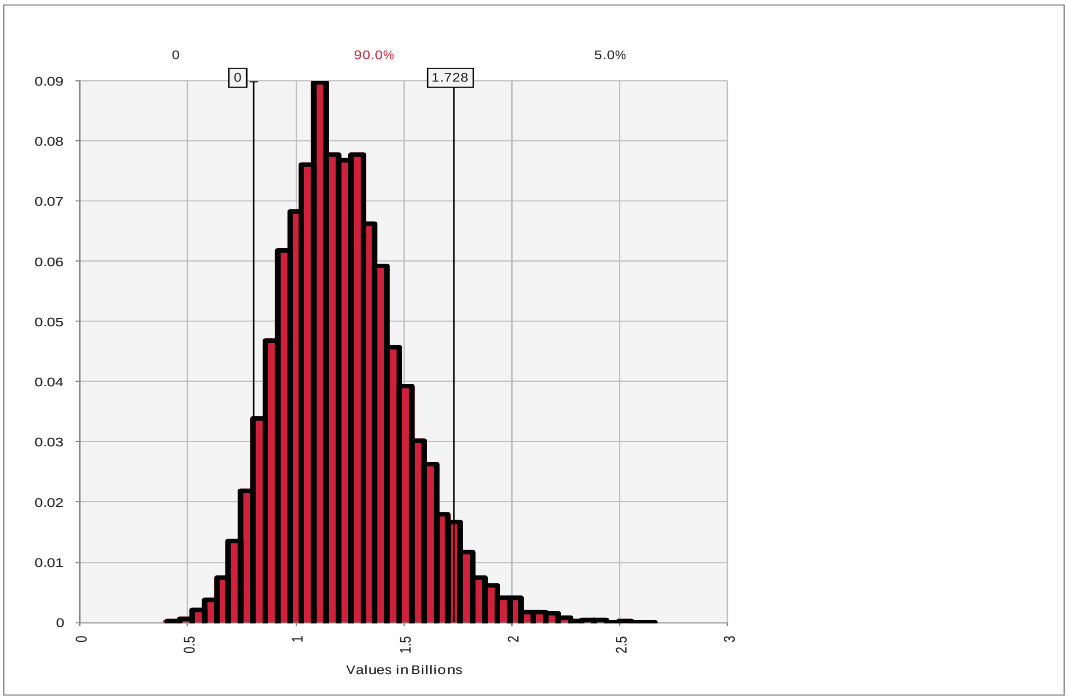
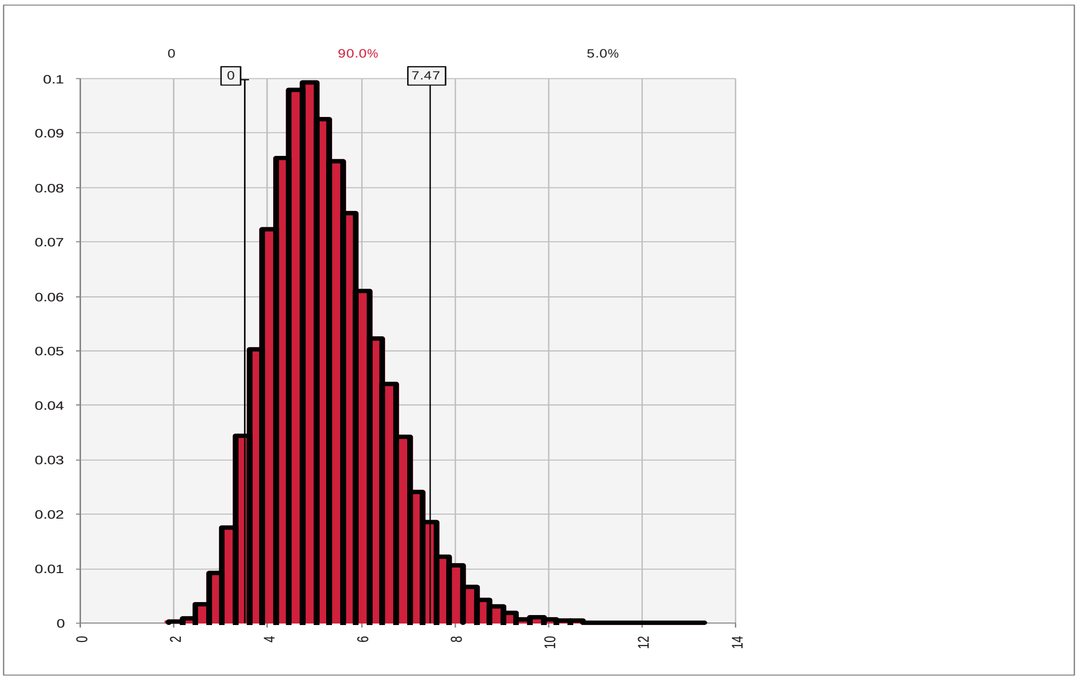


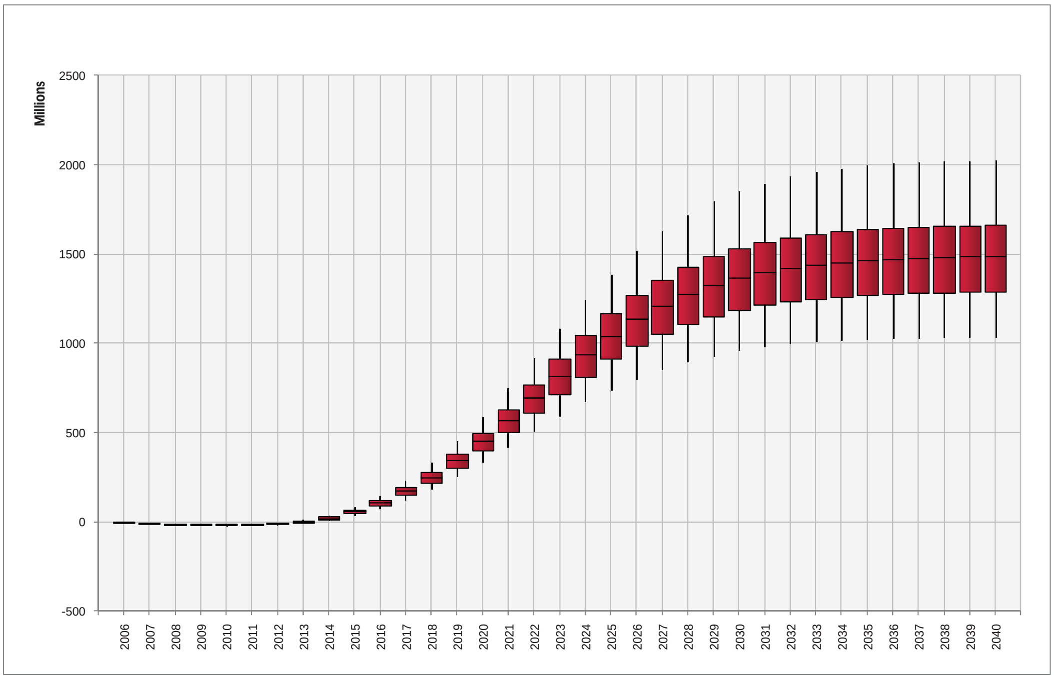
Figure 6: The relative frequency distribution of the BCR for the time horizon 2033 with a 5% discount rate. Mean is 5.26 USD with a standard error of 1.25



Both Figures 5 and 6 show that NPV and the BCR are well above zero and one. The mean NPV is 1.22 billion USD and the mean BCR is 5.26, again, at a 5% discount rate, both showing a substantial payoff to the vaccination program, even under conservative measures. Table 6 also shows the effect of changes in the discount rate on these ratios. At a 7% rate NPV is 877 million and the BCR is 5.06. It is also important to note from Figure 5 that, with a 5% discount rate, the NPV for this vaccination program does not become positive until 2013, or only after 8 years of the program. It thus takes some period of time for positive returns to emerge.

Finally, rather than assuming ongoing containment, the CBA results change considerably if at some point FMD is no longer just contained, but eradicated. We look at two cases. First, rather than assume a containment process that arbitrarily 'winds down' to zero newly infected cows, we simply assume the same pattern of containment and newly infected cows but with complete eradication in the year 2014, as if the current vaccination program is renewed for another four year period. After 2014, by assumption, there is thus no newly infected FMD animals and the vaccination program (and its cost) ends. Figure 7 shows net present values for this case.

Figure 7: Net present values assuming eradication in 2014, so that the number of newly infected animals and the cost of vaccination is zero in year 2015 forward, at a 5% discount rate, for years 2006 to 2040



As expected, NPV now reaches a maximum in the year 2040 in Figure 7, with full saturation of the population. NPV is now 1.49 billion USD, with a standard error of 292 million (see Table 7). The present value of benefits in this case is 1.565 billion and the present value of costs is 77 million. Costs are much lower of course since the vaccination program ends in 2014, and benefits increase (since the number of newly infected cows also goes to zero), but not dramatically compared to the base case since the vaccination campaign is already relatively 'late' in the growth process.

The second case is where eradication occurs in 2020, consistent with the OIE (2007) projections for FMD eradication for Vietnam. We again assume the same pattern of newly infected animals and the cost of vaccination program until 2020. Table 7 contains the relevant CBA ratios. NPV for eradication is lower for eradication in 2020 as expected, compared to eradication in 2014, but higher than the base case. Nevertheless, it is important to note that although cost measures vary considerably across the two cases (eradication in 2014 and 2020 in particular), there is little difference in net present benefits. The containment and eradication exercise is thus occurring relatively late in the FMD spread process, so much of the gains have already been dissipated.

Table 7: NPV and BCR relative year of eradication, compared to the base case of ongoing containment

Program/Year	BCR	Net Present Value (million USD)	Net Present Benefit (million USD)	Net Present Cost (million USD)
Eradication in 2014	20.35	1,488	1,565	77
	[3.87]	[292]	[292]	[2.83]
Eradication in 2020	11.46	1,427	1,564	137
	[2.32]	[29,326]	[29,325]	[10.72]
Base Case Ongoing Containment	5.26	1,220	1,513	294
to 2033	[1.25]	[285]	[282]	[43]

3.5 Qualifications

There are a number of qualifications to make to the above results. First, the measure of 1.22 billion USD in net present value from the vaccination program must be seen as a very conservative measure. There are a number of reasons for this. The calculations assume that the vaccination program simply maintains the pattern of newly infected animals (based on the stratified Monte Carlo draws) over the period of observed data (from July of 2007 to the end of 2008). This is still relatively early in the vaccination program. Instead, of the same pattern of new infections, it is more likely that the vaccination program will further decrease the mean and variance of new infections. If this is the case, the BCR and the net present value of benefits will be much higher, of course. As shown, the simulated case of eradication by the end of 2014 generates a NPV of 1.49 billion USD and a BCR of 20.35. Something less than full eradication (i.e., containment levels with a low mean and variance for newly infected animals) will carry comparable net benefits. The measure of 1.22 billion is also conservative is then sense that any spillover benefits from cows to pigs is ignored. This could be considerable if there is a vector for FMD that runs largely from cows to pigs. The gains from not having a trade ban for exporting beef if Vietnam is declared FMD free, or there are FMD free zones in Vietnam, is also not considered. Although this is not a issue at the moment, since Vietnam is a net importer of beef, it could represent a substantial potential loss in the future.

The second qualification to the NPV measure of 1.22 billion is that the calculation assumes that vaccination remains as effective in the future as it is now. In other words, it assumes that new strains of FMD do not enter the country, or if they do an appropriate vaccine can be deployed to counter their effects in the same manner as given in the stratified Monte Carlo exercise for newly infected animals. Finally, in a related manner, the calculations also assume no new incursions of FMD, and especially incursions that go undetected in zones without control. This seems likely under the current program, given that the entire border areas are control zones, with 100% vaccination, but with lack of restrictions on movement controls FMD outbreaks could still occur.

4. Closing Remarks and Recommendations

Buffaloes and cows are the symbol of wet rice culture. Raising buffaloes and cows is a tradition in rural Vietnam, and they are raised and used extensively for ploughing and other farm duties. According to MARD (2006b), out of a total 13 million farm households, roughly 4 million households have (on average) 1.6 cows per household. Buffaloes and cows not only help farmers in their production but also are often the most important depository of savings or the measure of household assets. Indeed, many poverty eradication projects provide loans to the farmers to make investment in raising cows. The 'Hybrid-cow Raising Project for Poverty Reduction' in Kon Tum, the cow lending project in Binh Thuan, or loans to ethnic minority households to buy cows in An Giang (VASS, 2009) are good examples of this. The vaccination program against FMD, the focus of this report, and other public policies that protect the stock of rural assets, including cows and buffaloes, are essential in Vietnam.

The CBA analysis in this report highlights the importance of the vaccination program. Even with the most conservative measures and methodology, the gains from the program are substantial at a NPV of 1.22 billion USD. This is equivalent to 82 million USD every year, in current dollars, from 2006 to 2033, with a BCR of 5.26. NPV can also increase substantially to nearly 1.5 billion USD, depending on the time at which full eradication from the program can be declared.

There are several policy recommendations that flow from these results. First, calculations of net present value show that although the overall gains are substantial, positive returns do not occur until year 8 of the program, or in 2013. Current planning in Vietnam is to re-evaluate the effectiveness of the program in 2010, when the staged funding of the current vaccination program formally ends. The CBA results thus argue for continued funding of the vaccination program past 2010. The full measure of the program's effectiveness will partly depend on results for the number of newly infected FMD animals in 2009 and 2010, data yet to be known. Hopefully, the mean and variance of the number of newly infected animals will fall, but even if the same pattern of newly infected animals occurs, it is clear that to realize the benefits of the current vaccination program it should be extended beyond 2010.

Second, given the nature of net present value in each year of the program, it seems clear that a more aggressive vaccination program may be beneficial. The call for eradication in 2020 (OIE 2007), is late in the time horizon, where much of the net benefits are already dissipated. Earlier eradication, and clearly so since the reduced costs of winding down the vaccination program early are substantial, generates considerably more net present benefits. Of course, earlier eradication may require more resources now to vaccinate (i.e., more than the roughly 11 billion USD that is already spent per year), but if a more aggressive vaccination program can lead to even earlier eradication, or at least fewer amounts of newly infected animals, the extra gains are more than worth the extra expense.

In this regard it would be worthwhile to investigate the trade-off between more vaccination and containment expenditures now, and the likely sequence of newly infected animals and the time of declared eradication. Best practice would equate the extra costs of adding to the containment program, with increased vaccination, to the marginal benefits of earlier eradication or less infected animals.

In addition, it is important to examine whether there are sufficient measures in place for early detection of FMD in an area. Spending more on blood tests for local surveillance can also increase benefits substantially.

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