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ECONOMIC LOSS CAUSED BY SPAM MAIL IN JAPANESE INDUSTRIES

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—Abstract—

Spam mail is a nuisance for most Internet users. Recently, spam mail has been shown to cause large economic losses in industries. The purpose of this paper is to quantitatively analyze the negative economic effects caused by spam mail. Concretely, we calculate the loss of GDP in Japanese industries through a production function. In addition, we examine whether or not a difference exists in economic loss by spam mail across industries. Finally, we discuss the effectiveness of spam mail countermeasures.

Key Words: *Spam mail, Production Function Model, Economic Loss*
JEL Classification: D24, C13, L86

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1. INTRODUCTION

An advanced and high-speed Internet has long been used not only in individual life, but also in firms as business tools. Moreover, E-mail is used as a tool for achieving smooth communications. Compared with post mails, E-mail is cheaper, and provides a quicker access to information. With the spread of the Internet the number of individuals having E-mail accounts in their firms or schools has grow. For instance, Bulkley and Van Alstyne (2007), as well as other researchers, have shown how E-mail and various ICT (Information and Communication Technology) contribute to management performance and organizational reformation[1].

On the other hand, cybercrimes using E-mail are increasing rampantly, and spam mails play the main role in these crimes. Against a background of progress in advanced ICT, spam mails have become a serious social and economic problem. A decrease in information network security has caused an increase in sophisticated cybercrimes. This problem has been pointed out since the creation of the Internet, but a "vicious circle" among spam mail senders (called spammers), recipients, and policy makers continues to be repeated. That is, we still have not been able to find effective and valid countermeasures and/or policies against these sophisticated cybercrimes.

According to Symantec (2007) and other reports, about 80%-90% of the number of E-mails on the Internet are spam mail. Floods of spam mail exist on the Internet because of botnets, which have expanded through P2P networks. Using botnets, it is easy to collect E-mail addresses and to send E-mails all over the world simultaneously. Botnets are used not only for sending spam mails, but also for various attacks such as DoS, Denial of Service. They become Internet threats. See Lee, Wang and Dagon (2008) about research on botnet detection. Black markets exist in which the list of collected E-mail addresses and botnets are bought and sold.

Through tools of natural science such as information engineering, many researchers have been aggressively accumulating research on technical countermeasures using filtering, especially Bayesian filtering against spam mails, for example; Sahami *et al*. (1998), Androutsopoulos *et al*. (2000), Gansterer (2005), and Yu and Xu (2008). Although these techniques have achieved a certain result, they have not become fundamental countermeasures.

On the other hand, in the fields of social science such as economics and business administration, very little research on the social impacts of spam mail has been carried out. We consider the following reasons for this lack of social science research on spam

[1] Shinozaki (2003) and Takemura (2008) give positive (empirical) analyses on some positive impacts of ICT investment in Japan.

mails: (1) Spam mails in the period before advanced and high-speed Internet access provided only a minor impact on economy and business; (2) previously, researchers in economics and business administration paid attention only to the positive effects of ICT; (3) no appropriate framework to analyze the impact existed, and (4) the dearth of data concerning spam mails. People may harbor the illusion that ICT gives a bright picture for the future and that the negative effects of ICT are small overall.

Since botnets have expanded rapidly and serious crimes have increased recently, it is more important than ever to promote qualitative and quantitative analysis in research on the negative impact caused by spam mail from the view of economics and business administration.

In this paper we introduce previous research that analyzes economic losses by spam mail quantitatively. Ferris Research (2003) reported that the cost of spam mail to corporate organizations in the United States was 8.9 billion dollars in 2002. Rockbridge Associates (2004) reported that the labor loss caused by spam mail amounted to 21.6 billion dollars per year when wasted time was valued at the average U.S. wage. Ebara, Ukai and Takemura (2005) reported that the total amount of labor and capital losses were 17 billion dollars and 22 billion dollars, respectively, in Japan in 2004. However, these authors measured only the labor loss caused by spam mail. Note that we have not only used direct damages such as labor loss, but also indirect damages such as GDP loss and a decrease of labor productivity caused through productive activity. In the following research, the indirect damage is measured. Ukai and Takemura (2007) used a production function to estimate GDP loss caused by processing spam mail in Japan. The amount of GDP loss was about 500 billion yen in 2004. Similarly, Takemura and Ebara (2008a, 2008b) found that the amount of GDP loss was about 500 billion yen in 2004, which substantially decreased labor productivity. In addition, Nippon Information Communications Association (2008) estimated the amount of GDP loss was 730 billion yen in 2006. From these results, it is obvious that spam mails impede certain positive economic effects and that the negative impact is too large. This is a serious global problem.

In this paper, as a first step to this kind of research, we use a simple and orthodox economic framework and quantitatively analyze the (negative) economic impact of spam mails. Concretely, under the framework used in Ukai and Takemura (2007), we analyze economic impact using panel data from industry level data. By using the results of a Web-based survey that Nippon Information Communications Association conducted in October 2007, we clarify the industrial impact of spam mail. In other words, we show how much GDP loss is caused by the labor loss of processing spam mails in each industry and by using these results. Then, we discuss spam mail countermeasures and policies.

This paper consists of the following sections. In section 2, we discuss the negative effects caused by spam mail. Section 3 explains a production function approach and presents the data sets used in this paper. In section 4, we show estimation results and measure the impact of spam mails. Finally, we present a summary and our future directions in section 5.

2. NEGATIVE EFFECTS CAUSED BY SPAM MAILS AND SPAM MAIL COUNTERMEASURES

Here, we briefly introduce negative economic and social effects caused by spam mails, and the countermeasures as an outline. Table 1 shows a summary of some negative effects (damages) caused by spam mails. Note that in this paper we focus on only labor-time loss, and we attempt to quantify the damages concerned with this loss of labor time[2].

From Table 1, we can point out that risk originated by spam mails have raised.

Table 1: Some Negative Effects Caused by Spam Mails

Object	Content
Industries and Firms	Loss of Labor Time Decreasing Labor Productivity (Decreasing Motivation and Morale) Over-Investment in System Assets such as Mail Servers Loading Networks such as Delays in Loading Networks Destruction of Information System Asset Loss of Business Chance, and Opportunity Loss of Important Mails Concerned with Business Loss of Confidence and Decreasing Stock Prices Overload to System Engineers (Branch) and Call Center Violation of Intellectual Rights and Property (Cyber) Crime such as Phishing
Individuals	Leisure Time Loss Decrease of Living (Satisfaction) Level Uneasiness and distrust of the Internet (Cyber) Crime such as Phishing

To reduce these damages, countermeasures and investment are needed. There are various countermeasures; the filtering technique, OP25B (Outbound Port 25 Blocking) and IP25B (Inbound Port 25 Blocking), which control sending and receiving mail, and Certification technologies. Individuals implement spam mail countermeasures at endpoint by using anti-spam software, and firms implement countermeasures on an internal network by using network filtering techniques and other techniques, and Internet Service Providers

[2] We will attempt to quantify other factors in addition to labor-time loss. We have begun to quantify individual damage such as leisure-time loss. See Nippon Information Communications Association (2008).

(ISPs) implement countermeasures over entire networks by using OP25B and network filtering[3]. Though we do not introduce the details of each technique here, we can say that OP25B by ISPs are effective in Japan[4]. Of course, countermeasures at each level become indispensable because implementing OP25B by ISPs is not a fundamental countermeasure[5]. Many techniques do not correspond to spam mails since there are false positives and false negatives. Therefore, we have to think deeply about human management when we install and operate information systems and software.

Individuals, firms, and ISPs have a limited number of countermeasures against spam mails. Government has to implement policy on the regulation of spam mail from foreign countries, maintenance of a legal system such as penal regulations, awareness campaigns, and technological development support. Recently the Japanese Government has implemented the following procedures: a group for international cooperation concerning spam mail, strengthening of penal regulations of spam mail, awareness campaign, and botnets' extermination activity that contributes to the expansion of spam mail. Parts of these procedures may not be effective at all from a short-term point of view, but they are necessary from the long term[6].

3. ECONOMIC FRAMEWORK

Many economic models are used to understand the impact of Spam mail: a production function model, an input-and-output (I/O) table model, and a computable general equilibrium (CGE) model. We should discuss in detail economic analysis on spam mail by using these existing macroeconomic models. However, we need to conduct economic analysis by using these macroeconomic models as a first step when we examine how much influence (loss) is caused in the economy, and when we make countermeasures and policy for spam mail[7]. Among them, we utilize a production function model in this paper

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[3] Spam mail countermeasures at endpoints have been criticized as not being a solution because they still occur.
[4] Japan Email Anti-Abuse Group (JEAG; <http://jearg.jp>) recommends OP25B and/or Sender Domain Certification.
[5] It is a mistake to think that ISPs should take responsibility for all spam mail countermeasures and make up the environment in which spammers cannot send spam mails and users cannot receive them since they are in upstream of the Internet. Originally, it is impossible for ISPs to implement such countermeasures because of money restriction and legal problems. Moreover, Takemura (2007) points out that some ISPs cannot enforce OP25B from the view of users' convenience.
[6] We will continue to check the effectiveness of strengthening penal regulations. Then again, the ratio of arrests may continue to be low even if regulations are strengthened. Before revising the act of promoting proper specific e-mail sending (called "tokuden hou"), the ratio of arrests was too low.
[7] Actually, the model and method in Ukai and Takemura (2007), which is similar to the current paper, created significant discussion in a workshop on spam mail (the Ministry of Internal Affairs

because this model can simply and plausibly represent the impact of spam mail on the economy.

3.1. Production function model

In this section, we explain a semi-macro production function[8]. This production function assumes that industry is one economic agent, and captures mathematically the relationship between input and output. The function is described as the following equation;

$$Y_j = f_j(K_j, L_j) \qquad (1)$$

where a subscript *j* indicates industry *j*, and Y_j, K_j, L_j represent industry *j*'s GDP, capital stock, and labor force, respectively. We suppose that f_j: $K_j \times L_j$ to R^+ is a function satisfying quasi-concavity and monotonicity.

We employ the Cobb-Douglas production function in equation (1) as the form:

$$Y_j = A_j K_j^{\alpha_j} L_j^{\beta_j} \qquad (2)$$

where A_j is the rate of technical progress.

We can measure negative impacts of spam mails toward GDP through this production function. Of course, spam mails affect both capital stock and labor. However, we focus on only the economic effects of labor in this paper[9].

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and Communications, Japan). See Nippon Information Communications Association (2008). Of course, we need to construct more suitable models based not only on semi-macroeconomic principles, but also on microeconomic principles.

[8] In this paper, we apply the production function approach using semi-macro data. Of course, we can use the approach using macro and firm data. When calculating the damage caused by spam mails and suggesting the countermeasures at industry level, it seems that this approach using semi-macro data is valid.

[9] Ebara, Ukai and Takemura (2005) point out the possibility that spam mails cause (vain) over-investment on ICT capital stock such as mail servers and Internet environments. They calculate the amount of over-investment on ICT capital stock to reinforce mail servers as spam mail countermeasures. Actually, as already see in section 2, from the viewpoint of the internal control, E-mail log management is requested. Therefore, firms would continue to overinvest in ICT, especially mail servers, unless they take adequate countermeasures against spam mails. Takemura and Ebara (2008a, 2008b) provide an economic model that considers damage to labor productivity caused by spam mails as one idea. We will analyze their model by using industrial data in the future.

We need to calculate labor loss, which is spent on processing the spam mail. Therefore, L_j in equation (2) includes labor for processing the spam mail, LS_j.

$$L_j = L'_j - LS_j \qquad (3)$$

where L'_j represents labor without processing the spam mail given that achieving the same level of capital stock is achieved. If LS_j is significantly utilized for production activity, not for processing the spam mail, GDP would increase. A variation of the GDP is:

$$\Delta Y_j = \beta_j A_j K_j^{\alpha_j} \Delta LS_j^{\beta_j - 1} \qquad (4).$$

The variation of the GDP calculated by equation (4) is called GDP loss by spam mail in this paper. Figure 1 shows the relationships.

Note that Takemura and Ebara (2008a, 2008b) calculate the GDP loss and test the decrease of labor productivity. In this paper, however, we calculate only this GDP loss since data is unfortunately restricted.

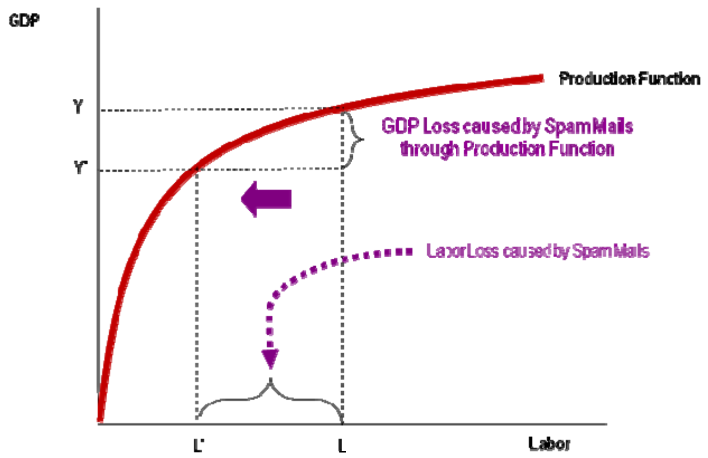

Figure 1: Labor Loss Caused by Spam Mails and GDP Loss

In this paper, under this economic framework, we measure GDP loss in each industry caused by spam mails. Since labor productivity is different in each industry, we can check which industry has suffered the worst damage by spam mails, and measure the negative effect of spam mails quantitatively.

3.2. Econometric method

By taking a logarithm of equation (2), and adding error term $\varepsilon_j(t)$ to the logarithm, we obtain the following equations:

$$\ln Y_j(t) = \ln A_j + \alpha \ln K_j(t) + (\beta + \sum_{j \in J} \lambda_j D_j) \ln L_j(t) + \varepsilon_j(t) \qquad (5)$$

where D_j is an indicator function which assigns 1 if the subscript is j. Otherwise, D_j assigns 0.

In this paper, we estimate coefficient parameters in equation (5) by using panel data analysis. If we consider the diffusion of the Internet and estimate parameters in equation (5) for each industry by time series analysis, then we at first face a statistical problem on sample size. Fortunately, panel data analysis can overcome certain kinds of statistical problems to some degree[10].

Here, we briefly describe the procedure of panel data analysis as follows. First, by using an F test we check whether or not individual effects in all industries are common in equation (5), that is, whether or not we reject the null hypothesis that $\alpha_j = \alpha$ for all j. If we disregard the differences of α_j and we estimate parameters in the equation above by cross- section data, each coefficient parameter might be underestimated. Thus, we have to examine the test. Next, if this null hypothesis is not rejected, we can efficiently estimate each coefficient parameter in equation (5) by Ordinal Least Squares (OLS). On the other hand, if this null hypothesis is rejected, we know that each industry has characteristics. Therefore, it is necessary for us to examine whether to treat α_j as a random variable or not. An econometric model in panel data analysis where individual effect is treated as a random (resp. Non-random) variable is called the Random Effect Model (resp. Fixed Effect Model). The parameters in the models are efficiently estimated by using the Generalized Least Squares (GLS) or the Least Squares Dummy Variable (LSDV), respectively. If parameters estimated by GLS and LSDV diverge, the model causes a specification error. Therefore, we examine to accept one of either fixed effect or random effect models. In general, we use χ^2 statistics and check the hypothesis on vertical relationships among individual effects and each explanatory variable. This test is called

[10] As a merit of panel data analysis, many data do not possess problems such as measurement error and bias. In addition, by connecting with cross- section data consisting of multiple years, the volume of information is extremely large, and we can solve some problems by multi-correlation, and by controlling variation that the economic agent possesses in time-series and cross-section data, so that we can know a common effect among the agents. Panel data analysis can supplement the fault (demerit) of both time-series and cross-section analysis.

the Hausman test. Refer to Baltagi (2001) and Greene (2003) for details of the panel data analysis.

3.3. Data set

The period for estimating coefficient parameters in production function in equation (5) is from FY 1996 to FY 2005. We use data on GDP (a hundred million yen) and capital stock (a hundred million yen) in each industry (agriculture, forestry, fisheries, the mining industry, construction industry, manufacturing industry, wholesale and retail trade industry, the finance and insurance industry, the real estate industry, transportation, telecommunication and the broadcasting industry, the electricity, gas, and water service industry, and the service industry). We use these data based on FY2000 as a benchmark. We use data from the System of National Accounts, easily obtained through the Website of the Ministry of Internal Affairs and Communications, Japan[11]. In addition, we calculate labor by total labor time × the number of employees, and we can easily obtain these data on labor statistics from the Labor Force Survey and Monthly Labor Statistics through the Website of the Ministry of Internal Affairs and Communications, and the Ministry of Health, Labour and Welfare, Japan[12].

LS_j, the labor for processing spam mails, is calculated in equation (6).

$$LS_j = SPT_j \times LD_j \times NE_j \times SRR_j \times RIU_j \qquad (6)$$

where subscript j means industry j, and SPT_j, LD_j, NE_j, SRR_j, and RIU_j represent spam mail processing time (per day), labor days, the number of employees, the spam mail reception ratio, and the ratio of Internet users, respectively.

From Nippon Information Communications Association (2008), we can acquire data on spam mail processing time per day in each industry. We obtain data on labor days and the number of employees from the statistics from the Labor Force Survey and Monthly Labor Statistics. And, we acquire data on the ratio of the Internet users from the "Communications Usage Trend Survey: Corporate/Office"[13]. Table 2 includes spam mail processing time per day (minutes), the spam mail reception ratio (%), the ratio of Internet users (%), and labor for processing spam mails (in thousands of hours per year)[14].

The transportation industry uses the most time to process the spam mail per day; 5.2 minutes. On the other hand, the finance and insurance industry and other service

[11] (http://www.esri.cao.go.jp/en/sna/menu.html)
[12] (http://www.stat.go.jp/english/data/roudou/index.htm and http://www.mhlw.go.jp/toukei/itiran/roudou/monthly/tyousa.html)
[13] http://www.johotsusintokei.soumu.go.jp/english/
[14] They assume that labor days per month are 20 days in every industry.

industries use the least time to process spam mails per day; 3.3 minutes. The average time to process the spam mails per day is about 4.0 minutes.

Table 2: Data on Spam Mails

Industry	spam mail processing time per day (minutes)	spam mail reception ratio (%)	ratio of Internet users (%)	labor needed for processing spam mails (in thousands of hours per year)
Agriculture, Forestry, Fisheries and Mining	4.0	76.0	27.0	1597
Construction	3.6	73.0	55.6	23772
Manufacturing	4.1	71.6	38.8	47071
Wholesale and Retail Trade	3.7	67.7	31.8	36191
Finance and Insurance	3.3	55.3	33.5	4003
Real Estate	3.6	66.9	59.8	2638
Transportation	5.2	60.4	30.1	11435
Telecommunication and Broadcasting	4.0	66.7	35.6	2338
Electricity, Gas, and Water Service	4.8	57.9	50.5	2088
Information Service	4.2	65.4	35.6	3875
Medical Treatment and Welfare	3.8	73.9	35.6	17715
Education and Research Support	4.2	78.3	35.6	11272
Other Services	3.3	64.8	35.6	23918

By summing the labor (labor time) needed in each industry for processing spam mails in Table 2, we obtain the total labor time, which is labor loss in Japan. The labor loss is 2 hundred million hours per year in Japan. The manufacturing industry, in particular, spends 47 million hours per year to process spam mails.

4. ANALYSES

By using data explained in the previous section, we estimate coefficient parameters in equation (5). First, we gain a result by using a dummy variable for each industry. As a result, although each estimated coefficient parameter is statistically significant, estimated coefficient β + estimated dummy variable does not satisfy sign conditions; the coefficient parameters are negative. In other words, these results are consistent with the theoretical production function. Therefore, we use some specific dummy variables and estimate coefficient parameters in equation (5) again. The results are shown in Table 3[15]. For reference, we also show the result of a Plain OLS in Table 3.

Table 3: Estimation Results

	Plain OLS		Fixed Effects		Random Effects	
	Estimated Coefficient	t-statistic	Estimated Coefficient	t-statistic	Estimated Coefficient	t-statistic
A_i	2.292	2.572			-1.246	-0.900
α	-0.033***	-0.466	0.519***	9.354	0.487***	9.253
β	0.387***	10.476	0.439***	5.274	0.288***	5.578
γ_1	-0.068***	-12.749	-0.323***	-2.587	-0.080	-4.897
γ_2	0.020***	3.053	-0.380**	-2.224	-0.011	-0.688
Adj. R^2	0.811		0.998		0.706	
	F(8, 77)=921.08*** CHISQ(4)=12.411***					

Note: D_1=agriculture, forestry, fisheries and mining industry, D_2= manufacturing industry.
***: p<1%, **: p<5%

First, we run the Hausman test to check which fixed or random effects' models are selected in panel data analysis. As a result, we accept the fixed effects' model at 1% significance level.

Next, we check the sign condition of each coefficient parameter in the fixed effects of Table 3 and discuss the significance of the estimated coefficients. Estimated coefficients α and β are 0.519 and 0.439 at 1% significance level, respectively. Estimated coefficients γ_1 and γ_2 are negative at a 1-5% significance level. The latter result implies that the labor productivity of agriculture, forestry, fisheries and mining, and the manufacturing industry are less than in other industries.

By substituting each labor loss in Table 2 with a production function using estimated coefficient parameters in Table 3, we can calculate GDP loss in each industry caused by spam mails[16]. The results are shown in Table 4.

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[15] Recently, it has been pointed out that variables used in this paper such as real GDP are very likely to be unit root (integrated) processes. Thus, strict analysis should employ co-integration techniques, as is now routinely done in applied time-series econometrics. This paper is positioned as a first step to this kind of research, and we will test and refine econometric methods the same as in the model in the future.

[16] When we calculate the losses by equation (4), we use capital stock of FY2005 in each industry.

Table 4: GDP Loss Caused by Spam Mails

Industry	GDP Loss (in billions of yen)
Agriculture, Forestry, Fisheries and Mining	6.36
Construction	26.17
Manufacturing	0. 42
Wholesale and Retail Trade	36.66
Finance and Insurance	86.02
Real Estate	168.14
Transportation	63.73
Telecommunication and Broadcasting	47.00
Electricity, Gas, and Water Service	145.29
Information Service	161.82
Medical Treatment and Welfare	68.98
Education and Research Support	88.90
Other Services	58.29

By summing GDP loss in each industry in Table 4, the GDP loss becomes about 960 billion yen per year in Japan. GDP losses in real estate and information service industries are over 160 billion yen. In the real estate industry, where the number of employees is less than in the other industries, and with a rate of the whole GDP in Japan at about 12%, the loss is especially large. Nippon Information Telecommunications (2008) shows the results of a Web-based survey in which spam mail countermeasures are not implemented in the Japanese real estate industry. This result of the Web-based survey seems to match our estimated result. At the same time, this proves the necessity of spam mail countermeasures.

4. SUMMARY AND FUTURE WORK

In this paper, we quantified negative economic effects (damages) such as labor loss and GDP loss in each industry caused by the spam mails under a simple economic framework. As a result, we found that the amount of GDP loss in Japan is about 960 billion yen, and that there is also a difference in loss by industry. In addition, we found that in the industries with a large loss, this loss was caused either by having a large number of employees, by implementing inadequate countermeasures, or by not implementing countermeasures at all, such as in the real estate industry. This result implies the necessity of spam mail countermeasures. Furthermore, our framework teaches what and how different levels of technologies and countermeasures should be introduced into each industry. That is, we can find an adequate level of investment for spam mail countermeasures.

We suggest installing anti-spam software with filtering at the endpoint to individuals, full-fledged introduction of OP25B to ISPs, and authentication as “sendmail authentication” to all firms as effective spam countermeasures. In addition, the government should make policy and coordinate environments such as the development of legal systems, and foreign negotiation, for example. As long as spam mail exists, mixing various countermeasures and policies is a method of minimizing spam damage. However, we do not imply that this is enough to stop labor time losses.

Finally, we discuss perspectives and remaining problems. The problem of the loss caused by spam mail is not only specific to Japan. Using the same framework, we can calculate the GDP loss and labor loss globally. To this purpose, we must accumulate data on spam mails and build extended economic models.

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BIBLIOGRAPHY

[1] Androutsopoulos, Ion, John Koutsias, Konstantinos V. Chandrinos, George Paliouras, Constantine D. Spyropoulos (2000), “An Evaluation of Naive Bayesian Anti-Spam Filtering” *Proceedings of the Workshop on Machine Learning in the New Information Age, 11th European Conference on Machine Learning*, pp.9-17.
[2] Baltagi, Badi H. (2001), Econometric Analysis of Panel Data (Third Edition), New York: Wiley.

[3] Bulkley, Nathaniel and Marshall Van Alstyne (2007), "Why Information Should Influence Productivity" *MIT Sloan Research Paper*. No.4680-08.
[4] Ebara, Hiroyuki, Yasuharu Ukai and Toshihiko Takemura (2006), "Estimated Economic Losses by Spam Mails" *RCSS Discussion Paper, Kansai University*, No.33. (in Japanese)
[5] Ferris Research (2003) "Spam Control: Problems and Opportunities." Ferris Research.
[6] Gansterer, Wilfried, Michael Ilger, Peter Lechner, Richard Neumayer, Jürgen Straub (2005), *Anti-Spam Methods -State of the Art*, http://www.ifs.tuwien.ac.at/~neumayer/pubs/GAN05_report.pdf [Accessed 20.6.2008]
[7] Greene, William (2003), Econometric Analysis (Fifth Edition), New Jersey: Prentice Hall.
[8] Lee, Wenke, Cliff Wang, and David Dagon (2008), Botnet Detection: Countering the Largest Security Threat, New York: Springer.
[9] Nippon Information Communications Association (2008), *Inspection slip of Influence That Spam Mail Exerts on Japanese Economy*, http://www.dekyo.or.jp/ (in Japanese). [Accessed 20.6.2008]
[10] Rockbridge Associates (2004), "National Technology Readiness Survey: Summary Report, 2005" Rockbridge Associate.
[11] Sahami, Mehran, Susan Dumais, David Heckerman, and Eric Horvitz (1998), "A Bayesian Approach to Filtering Junk E-mail" *Learning for Text Categorization - Papers from the AAAI Workshop*, pp.55-62.
[12] Shinozaki, Akihiko (2003), Economic Impact of Information Technology Innovation, Tokyo: Nippon Hyoron-Sha. (in Japanese)
[13] Symantec (2007), *The State of Spam A Monthly Report - March 2007*, http://www.symantec.com/avcenter/reference/Symantec_Spam_Report_-_March_2007.pdf [Accessed 20.6.2008]
[14] Takemura, Toshihiko (2007), "The 2nd Investigation of Actual Conditions Report on Information Security Countermeasures for Internet Service Providers" Kansai University. (in Japanese)
[15] Takemura, Toshihiko (2008), Economic Analysis on Information and Communication Technology, Tokyo: Taga-shuppan. (in Japanese)
[16] Takemura, Toshihiko and Hiroyuki Ebara (2008a), "Spam Mail Reduces Economic Effects" *The Proceedings of the 2nd International Conference on the Digital Society*, pp.20-24.
[17] Takemura, Toshihiko and Hiroyuki Ebara (2008b), "Economic Losses Caused by Spam Mails in Japan" *Journal of International Development*, Vol.8, No.1, forthcoming (September, 2008)
[18] Ukai, Yasuharu and Toshihiko Takemura (2007), "Spam Mails Impede Economic Growth" *The Review of Socionetwork Strategies*, Vol.1, No.1, pp.14-22.
[19]Yu, Bo and Zong-ben, Xu (2008), "A Comparative Study for Content-Based Dynamic Spam Classification Using Four Machine Learning Algorithms" *Knowledge-Based Systems*, Vol.21, pp.355-362.