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**English Abstract**

# Human induced pluripotent stem cells for cell therapy in Huntington's disease

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## Abstract

**Background and Aims:** Huntington's disease (HD) is a neurodegenerative disease caused by a mutation in the huntingtin gene (*HTT*). The extended CAG repeat ultimately leads to loss of medium spiny neurons (MSNs) in the striatum of the HD brain. Cell replacement therapy using primary human fetal tissue has shown 'proof of principle' as a strategy to treat this genetically inherited disease. However, alternative cell sources need to be identified to overcome the ethical and logistical issues that are associated with using human fetuses. The whole ganglionic eminence (WGE) is an originate area developing to the striatum, therefore making this an interesting cell resource to generate iPS cell line which more readily to differentiate into theoretically authentic and functional MSNs-like cells.

**Methods:** Here we attempt to generate safety iPS cells by introducing reprogramming factors using *piggyBac* Transposon transduction system to human fetal fibroblasts and fetal WGE which theoretically have the potential to be more readily reprogrammed and are genetically unrelated to the host. At the same time, we directly differentiate into neural progenitor cells and ultimately MSNs-like cells by using adapted protocol from published protocols available at the moment.

**Results:** The iPS cell lines so established demonstrated many similarities to human embryonic stem (ES) cells in terms of their morphology, surface antigens expression, and proliferation rates. These iPS cells were then successfully manipulated to differentiate into neurons in culture by which expressed standard markers of premature and mature MSNs, Ctip2 and DARPP32; a proportion of these cells exhibited the general neuronal electrical properties of spontaneous and inducible action potentials. *In vivo* differentiation of these iPS cells when transplanted into quinolinic acid (QA) lesioned rats showed good graft survival and differentiation into MSNs-like cells, as assessed by *hunu* and DARPP32 expression.

**Keywords:** *iPS cells, Huntington's disease, cell therapy, medium spiny neurons*

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# The fabrication of massive sensor detecting cortisol stress hormone based on molecular imprinted polymer as artificial antibody

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## Abstract

Nowadays, stress is becoming increasing in modern life. The people's behavior in work and money is the main reason causes a chronic stress which can affect diseases and aging in biological way. Cortisol has been used as a well-known commercial stress biomarker. A homeostasis response to psychological stress is indicated by an increased level of cortisol produced in hypothalamus-pituitary-adrenal (HPA) axis. This study revealed the fabrication of 342.3 nm-core shell molecular imprinted polymer integrated on massive response by quartz crystal microbalance (QCM) technique. The physical properties of Cortisol-MIP were characterized by means of electron and atomic force microscope techniques. The binding characteristics were evaluated using covalent patterns changing in Fourier transform infrared (FTIR) spectra which were related to massive response by quartz crystal microbalance (QCM) technique. The cortisol-MIP particles enhanced the surface area of cortisol binding cavities that allowed high performances of specificity and selectivity. The performance of cortisol-MIP modified SPCE displayed a wide detection range and high selectivity compared to three other glucocorticoids analogs. The achievement goal of cortisol stress sensor is awaking the people to know their stress in biological term and changing behaviors for a well-being.

**Keywords:** Cortisol, stress hormone, Molecular imprinted polymer (MIP), Sensor, Quartz crystal microbalance (QCM)

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# Comparative of high throughput screening assay development for anthelmintic in *Trichinella spiralis*, *Heligmosomoides polygyrus*, and *Caenorhabditis elegans*

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## Abstract

Parasites have been problems long time ago. The parasite causes different type of diseases, ranging from self-curing skin lesions to fatal visceral infection, and there are few drugs for their treatment. Supremely, new drugs for the treatment of helminths are required as parasite resistance is limiting the number of drugs available for clinical use and multiple-drug treatment regimens appear to be the only way to avoid treatment failure. Conventional screens anthelmintic drugs have been limited; this may be due to a number of factors including costs involved, labour intensive, or a lack of appropriate compounds. In this project a novel screening will be used to identify new drugs that can be used for the treatment of nematode infection. Compounds will be screened against different species of nematodes. A novel quantitative assay system will be determined for nematode parasites. Then active compounds have been identified before *in vivo* efficacy will be determined. Resazurin (7-hydroxy-10-oxido- phenoxazin-10-ium-3-one) is a redox dye, which shows both colorimetric and fluorometric change related to cellular metabolic activity. Metabolism of resazurin results in conversion from the oxidized (or non-fluorescent) blue form to the reduced (fluorescent) red form. We compared the performance of resazurin assay in *in vitro* cultures of the parasitic nematodes *Trichinella spiralis*, *Heligmosomoides polygyrus* and the free-living nematode *Caenorhabditis elegans*. The assay was performed in 96-culture well plates with 200  $\mu$ l/ml in total volume and 10% v/v sterile resazurin solution. The general stages for screening in this project, included the validation of nematode number, the validation of solvent effect, the validation of standard drugs, the optimization of incubation periods, and screening results. *T. spiralis* muscle larvae (L3) digested from infected mice, *H. polygyrus* L3, cultured from faeces, and *C. elegans* maintained on *E. coli* were enumerated and dilutions added to wells of a 96 well tissue culture plate in triplicate. Albendazole (ALB), Fenbendazole (FEN), Ivermectin (IVM), Nitazoxanide (NIT), and Levamisole (LEV) were studied as standard drugs for assessment of anthelmintic activity. The results demonstrated that ALB and FEN were not suitable as they precipitated during the assay while IVM was not effective against all nematodes in the assay. LEV was not toxic to *H. polygyrus* L3 and *C. elegans* while NIT was not toxic in *H. polygyrus* L3. However, NIT and LEV were effective against *T. spiralis* L3. The optimization of incubation time was considered at various time points and indicated that the optimum culture period was 72 hours. Furthermore, this study determined that adding resazurin solution prior to incubation was not only more convenient, but also provided the same result as adding resazurin solution at different time points during incubation. A total of 90 novel compounds were screened at optimized condition, these compounds included natural products and modified chemicals. We found 1 novel compounds, which demonstrated anthelmintic activity against *T. spiralis*. This study demonstrated that an *in vitro* 96 well plate resazurin method delivers a quantitative, simple, rapid, efficient, reliable, sensitive, safe and cost-effective screening assay. Moreover, *T. spiralis* L3 are good models for anthelmintic drug screening. To confirm the effectiveness of this compound in *in vivo* models, C57 mice were infected with *T. spiralis*. The mice were orally treated with novel compounds day 3 after infection. Moreover, the mice were treated with PBS and Oramec Drench® as a control and positive control, respectively. Then, they were euthanized by CO<sub>2</sub> seven days after infection. Opening the small intestine assessed intestinal burdens of *T. spiralis*. The results showed that orally delivered novel compounds could reduce intestinal burdens of *T. spiralis* but did not cause toxic effect inflammation in uninfected animal. The next steps will be confirming the effectiveness of this compound in muscle larvae *T. spiralis* and other species of parasites.

**Keywords:** anthelmintic, *in vitro*, *in vivo*, high throughput screening, parasites

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# Development of rapid test kit from aptmers for detection the Porcine Reproductive and Respiratory Syndrome Virus (PRRSV)

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## Abstract

The porcine reproductive and respiratory syndrome (PRRS) is a disease caused by PRRSV, the disease cloud be found in pregnant pigs and pigs. The result of disease is abortion, death and piglets immune deficiency that is cause of other infections. PRRS is a serious disease that causes of economic lose in farm in Thailand and the other country.

The gold prevention of outbreak from PRRSV is the pig screening before entry to the farm. And selected the infection pigs sort out for prevent the virus spread to the other pigs. Currently, detection of PRRSV-infected pigs can be done in two ways: real-time PCR (RT-PCR) and serologic methods by detecting antibody to antigen of PRRSV (enzyme linked immunosorbent assay :ELISA). Both of these methods still need to be done in the laboratory and takes time for the result. The study for develop of a method for rapid virus detection.

Aptamer is a single strand deoxy ribonucleic acid (ss-DNA) around 40 base that could be bind with the target such as small molecule, protein, cell, bacteria and virus. The application of aptamer can use with gold nanoparticle and develop to strip test for detect the virus. In this study found aptamer that can bind with PRRSV by capillary electrophoresis. And then test the specificity and sensitivity of the aptamer with colorimetric method and Quartz Crystal Microbalance (QCM).

**Keyword:** *Aptamer, PRRSV*

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# Potential of artisanal fisheries for safeguarding food security in the small fishing village of Bu Boi, Southern Thailand

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## Abstract

Over the last decade, the population growth rate has gradually increased from 6.3 billion in 2003 to 7.2 billion in 2013; it is expected to reach 9 billion in 2050. As a result, the world will require increased food supply in order to feed its predicted 9 billion people. Against the backdrop, the Sustainable Development Goals (SDGs), in particular SDG 2 (*‘End hunger, achieve food security and improved nutrition and promote sustainable agriculture’*) and SDG 14 (*‘Conserve and sustainably use the oceans, seas and marine resources for sustainable development’*), of the 2030 Agenda for Sustainable Development from the UN highlight the importance of small fisheries for developing countries to sustain basic food production and nutrition in order to safeguard global food security.

Thailand is amongst the significant producers and exporters of fish and fishery products in the world. It was estimated that Thailand’s production amounted to two per cent (1.6 million tonnes) of the global total marine catch in 2014. Thai marine fishery activities can be broadly classified into commercial fisheries, and artisanal or small-scale fisheries. The latter are supposed as an imperative component in nutrition, income and food security provision. However, there is little evidence available to affirm such assumption. Accordingly, the present study aims to examine the potential of a small fishing village to maintain its food security and beyond, and discusses opportunities as well as threats that artisanal fishery is faced with. Bu Boi, an artisanal fishing village on Thailand’s Andaman coast, was chosen as a study case. Field data was obtained through Participatory Rural Appraisal (PRA), combined with key informant interviews, focus group discussions, participant observation and field walks and questionnaire survey.

Our findings demonstrate that artisanal fishing communities like Bu Boi can provide a critical role in the provision of food and nutrition for local and regional areas, as especially marine fish and shellfish products provide the great majority of dietary animal protein. The majority of the population lives along the coast where they rely heavily on marine resources to provide them with a source of income as well as to sustain the community’s livelihoods. However, seasonal changes and natural disasters affect food availability in some periods. This study also suggests artisanal fishing village requires further support from governmental agencies to strengthen sustainable resource management and development of economic benefits in small fishing communities. This research will help to provide useful information to the Thai government’s policy planning and guideline development in order to maintain the country’s food security which is an essential dimension of the Food for the Future (one of ten targeted industries under “Thailand 4.0” economic model).

**Keywords:** *Small fishing village, food security, Thailand*

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**Enhanced selenocysteine of immune system  
in bacterial infected and uninfected rainbow trout (*Onchorhynchus mykiss*)  
fed on control diet and selenium supplement diet**

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**Abstract**

Bacterial infection in fish is an issue for the fishery industry and *aeromonas salmonicida* bacteria causes the infection in salmonid fish group including rainbow trout. Apart from vaccination for infection treatment, selenium (Se) supplemented diet has been proposed for boosting the immune system because Se is a component of the immune system in humans and animals. Se containing compounds like Selenocysteine (SeCys) is required in selenoproteins to maintain optimal immune functions. In this work, rainbow trouts were fed with a control diet and a Se enriched diet for 5 weeks to understand the accumulation of Se in different tissues of rainbow trout. Two subgroups of fish samples from each diet type were infected with bacteria to study the change of Se in different tissues. Se speciation method was developed for the SeCys separation from others Se species to determine the distribution of essential SeCys in different tissues. The total Se concentration was analyzed using inductively coupled plasma mass spectrometry (ICP-MS). There was a significant difference of Se concentration (with  $p > 0.05$ ) in every tissues between farmed fish fed on control diet and Se supplemented diet. The Se concentration decreased from gut, gills, spleen, brain, and muscle to skin. The developed speciation method (HPLC-ICP-MS) was used for the separation. The SeCys concentration decreased from spleen, gut, gills, brain, and muscle to skin, respectively. The change of SeCys concentration between normal fish and infected fish was significant in spleen, gut and skin, respectively. Hence, the bacterial infection might compromise selenoprotein concentration and thereby compromising immune functions.

**Keywords:** Selenium (Se) supplemented diet, Selenocysteine (SeCys), inductively coupled plasma mass spectrometry (ICP-MS)

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# **The immune response of rainbow trout to flagellin: antibody response and adjuvant potential**

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## **Abstract**

Vaccination is an effective approach against a variety of infectious diseases. However, in cases where vaccines are not completely efficacious it may be possible to trigger stronger, more effective responses to antigens to achieve better protective immunity against pathogenic infection. Based on their ability to induce innate responses, adjuvants have emerged as the best tools to enhance the efficacy of fish vaccination, and are typically co-administered with the vaccine. In this study, the potential of flagellin from *Yersinia ruckeri* (YRF) to be an immunostimulant or adjuvant has been investigated in rainbow trout. Initially the antibody response to flagellin was determined, since when used as an adjuvant flagellin would likely be an antigen as well as a pathogen-associated molecular patterns (PAMPs). When YRF was mixed with complete Freund's adjuvant it was able to induce YRF-specific IgM antibodies. These antibodies were able to neutralize YRF bioactivity, and reacted against the middle domain of YRF, as assessed in Western blot analysis. YRF was then combined with a protein antigen (VapA) as a mixture of the two proteins, or as a fusion protein, with the latter found to increase the antigen-specific IgM antibody response. These results suggest that YRF is a potent activator of host immune responses and can be used as an immune stimulant or adjuvant to improve vaccine efficacy.

*Keywords: Flagellin, adjuvant, vaccination, antibody titre, rainbow trout*

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# Heat shock proteins play roles in protection against acute hepatopancreatic necrosis disease-causing strain of *Vibrio parahaemolyticus* by induction of shrimp immune system

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## Abstract

Shrimp farming industry is economically important for Thailand generating tens of billions of baht of revenue per year. However, shrimp farming has been continuing affected by serious infectious disease outbreaks caused mainly by viruses and bacteria especially the white spot syndrome virus (WSS) and *Vibrio* species. In 2013, Thai shrimp production has declined nearly 50 percent because of the spread of a deadly disease outbreak named 'early mortality syndrome' (EMS) or acute hepatopancreatic necrosis disease (AHPND). Although it is expected that the shrimp production in Thailand will be improved in the future as shrimp farmers adopt several strategies to cope with the disease, however, the research to support disease control and prevention in shrimp farming remains very important for the sustainability of the industry

Acute hepatopancreatic necrosis disease (AHPND) caused by the bacterium *Vibrio parahaemolyticus* carrying toxin producing plasmid (VP<sub>AHPND</sub>), has led to severe mortalities in farmed penaeid shrimp throughout Asia. Our work, reported that a chronic non-lethal heat shock (chronic-NLHS) could enhance *Penaeus vannamei* (The pacific white shrimp) to be tolerant to VP<sub>AHPND</sub> infection. The results showed that the shrimp exposed to chronic NLHS had higher survival rate (>50%) than that of the non-heated shrimp control (20%) when they were challenged with VP<sub>AHPND</sub>. Furthermore, the qRT-PCR analysis revealed that the expression of heat shock proteins, *LvHSP70* and *LvHSP90*, as well as other immune-related genes, *LvproPO1* and *LvCrustin1*, were induced upon exposure of shrimp to chronic NLHS. Moreover, gene silencing of *LvHSP70* and *LvHSP90* eradicated the VP<sub>AHPND</sub> tolerance in the chronic NLHS shrimp and decreased PO activity. The recombinant *LvHSP70* (rLvHSP70) was successfully overexpressed in *E. coli* system and dose-dependent (100 nmol) of rLvHSP70 injection induced the expression of several immune-related genes (*LvMyD88*, *LvIKKε*, *LvIKKβ*, *LvCrustin1*, *LvPEN2*, *LvPEN3*, *LvproPO1*, *LvproPO2*, and *LvTG1*) in the shrimp immune system. Interestingly, rLvHSP70 enhances *P. vannamei* resistance to VP<sub>AHPND</sub> infection increasing survival rate from 20% (control group) to >75%. These results suggested that *LvHSP70* plays crucial roles in bacterial defense by activating shrimp immune system. Furthermore, to gain insights into the function of HSP70 in shrimp immune system. The *Artemia* (Brine shrimp) genome was used to identify HSP70s family resulting in more understanding of HSP70 function in shrimp. The knowledge gained on HSP70 related immune system of shrimp will lead to the implementation of powerful strategies such as use HSP70 supplement in shrimp feeding for controlling disease outbreaks in shrimp aquaculture.

**Keywords:** Heat shock protein; *Penaeus vannamei*, *Vibrio parahaemolyticus*, acute hepatopancreatic necrosis disease, chronic heat stress

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# Smart in Agriculture: the move to industry 4.0

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## **Abstract**

Industry 4.0 in Germany are currently widely applied. The application of this technology is not only implemented in the industrial sector, but also in almost every field, e.g. transportation, finance and tourist. The key to develop these products is to combine a specific technology with the IT, such as refrigerator which can communicate with user and exchange the information with other products.

As the technology of industry 4.0 evolves, the opportunity to integrate the devices from different industries is highly possible. The potential specialized Thai technology which has the capability to move into the industry 4.0 is "agriculture". If we are going to develop the agriculture in Thailand into industry 4.0, how should we start? Just controlling the sprayer to water plants from a mobile phone is not enough for agricultural products to compete in the international market and in the context of global social needs.

It was found that aquaculture in Thailand, especially shrimp product, is very important to the country both in terms of social and economic well-being. It could boost the one of the most export-value in the agricultural sector in year 2016. The shrimp production is developed in the form of industrialization which are involved from more than 1 million stakeholders. To improve the shrimp farming technology at a reasonable price, the "SmartAqau" system is hence developed. The system allows the farming to be managed using the technology of industry 4.0. Moreover, it can be systematically integrated with other smart farms. As developer of this technology, we found that it is essential to develop the facilities in agricultural industry to cope with digital transformation of the world. The SmartAqua aims therefore to build the infrastructure of agricultural systems to support the transition to digital farming. When this technology is fully accessible to farmers and consumers, the Smart Food and Smart Environment will be then available in the coming future.

*Keywords: industry 4.0, smart farm, shrimp, agriculture, aquaculture*

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# Immunological adaptations to bacterial infection pressure in eggs of great (*Parus major*) and blue (*Cyanistes caeruleus*) tits

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## Abstract

Both in the pre-and post-hatching stage, birds can encounter the danger of microbial infections that may lead to hatching failure and death. One of the parental strategies to protect the egg and future chick is depositing egg immune factors to the egg albumen and yolk. Here, we performed a follow-up study of great (*Parus major*) and blue (*Cyanistes caeruleus*) tits in the south of Ghent (Belgium) in which we analyzed interspecies differences in (1) the pathogen burden on the eggs, (2) the level of immune defenses the tits confer to the egg and (3) the effect both parameters on the reproductive success.

A screening of 70 great and 34 blue tit eggs revealed a similar eggshell microbiota composition (*Enterobacteriaceae*, *Lactobacillaceae*, *Firmicutes* and *Bacteroidetes*), but higher bacterial loads on the eggshell of great tits compared to blue tits. We found that great tits encounter this increased pathogenic threat by transferring more lysozyme and IgY to the egg compared to blue tits. Great tits only suffer a small reduction in hatching success compared to blue tits and no significant changes were observed in the overall brood reduction. This means that the increased immune investment in great tit eggs protects the future nestling. Statistical analysis pointed out that the species difference is the driving factor for the differences in immune allocation. Possibly due to a higher infection pressure, female great tits evolved through natural selection to a species that increased its immune investment into eggs to protect their offspring.

**Keyword:** pathogen pressure, antimicrobial proteins, immune investment, passerine

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# Parameter selection in limited data cone-beam CT reconstruction using edge-preserving total variation algorithms

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## Abstract

One major concern of the x-ray CT in medical analysis is the high radiation dose delivered to a patient during clinical exams. This is particularly true in the radiation therapy sessions where an x-ray cone-beam CT (CBCT) scan is needed at the beginning of each session to observe a patient's anatomical change in response to the treatments. One way to reduce the radiation is to reconstruct CT image from sparse-view projection data. However, when the number of projection views is reduced, the reconstructed result obtained from a conventional filtered back-projection (FBP) suffers some artifacts because the number of projection views are not theoretically sufficient for exact image reconstruction.

In this limited data scenario, the iterative reconstruction methods produce good quality images. A minimization problem of CT reconstruction can be performed using iterative algorithms by formulating the data-consistency constraint with additional regularization term. This term is used to select a unique solution out of the set of feasible solutions that agree with the available projection data.

Minimizing total variation (TV) norm of the image is widely used as a common approach for regularization. However, the over-smoothing in the reconstructed image is a main concern for TV regularization in CT image reconstruction. This is because the TV-based approaches uniformly penalize the image gradient regardless of the image structures. As a result, edges of the reconstructed image tend to be frequently over-smoothed, which leads to the loss of low-contrast information.

Another drawback of TV regularization algorithms is the presence of an initial set of parameters in the minimization of the TV norm. The set of optimal parameters are difficult to select and can only be determined by considerable numbers of trials and errors, which is a time-consuming and tedious process.

This study proposes a new algorithm called "adaptive-weighted projection controlled steepest descent (AwPCSD)" algorithm, which implements additional edge-preserving function. By doing so, the proposed AwPCSD algorithm will be able to preserve the edges of the reconstructed image better with less initial parameters to set than the well-known adaptive-steepest-descent-POCS (ASD-POCS) algorithm.

In addition, this work aims to analyse the sensitivity of initial parameters required for the TV regularization algorithms. These parameters play an important role for the reconstruction performance of the algorithms. It is useful to examine the sensitivity that the reconstruction image has to value change on these parameters, in order to know which ones to prioritize when tuning the algorithm. Ultimately, heuristics on how to choose this parameters are desired, to minimize or completely avoid rerunning the reconstruction with different parameters.

**Keywords:** *Cone-beam CT, total variation, edge-preserving function, iterative algorithm, parameter tuning*

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# **Matching truck-and-shovel operations in open-pit mines using statistical data – dispatching strategies, match factor, and age-based maintenance**

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## **Abstract**

Economics today force mining companies to maximize profit over the life time of a mine. Especially in the context of open-pit mines, it is essential to acquire production with minimum cost. The ability to reduce operation costs can be directly achieved by utilizing trucks and shovels in an efficient manner. Dispatching approaches in the literature have considered different objectives in varying degrees of sophisticated assignments ranging from simple heuristic rules to complex mathematical programming. However, most approaches assume that all trucks and shovels have the same operating performance or ignore the stochastic nature of the truck-and-shovel operations.

This research investigates one of the primary problems in an open-pit mine: efficient matching trucks and shovels. In other words, the aim is to determine the required number of trucks and shovels and their types to make the best match in order to satisfy the production target. This problem is investigated using different simulation and optimization models, which contain the behaviours of dispatching strategy, match factor, and age-based maintenance under an ideal operation and breakdown event.

The results of this research show that the match factor ratio is able to determine limits for an appropriate fleet size selection, and can be used to estimate the relative efficiency of existing fleets. However, it cannot be used alone for fleet optimization. The choice of truck dispatching strategies and heuristic truck dispatching methods plays a crucial role to minimize the queuing time. Maintenance schedules are necessary to reduce breakdown, directly influencing equipment availability. Optimal preventive and corrective maintenance schedules are proposed for different truck age levels, providing cost savings. These proposed models offer potential applications to any situations in which truck fleets are used to transport material.

*Keywords: simulation, match factor, heuristic truck dispatching methods, maintenance, open-pit mines*

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# **Utilising manipulative materials in multimodal classrooms for mathematical concepts understanding: equation-solving classes in a Finnish primary school**

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## **Abstract**

There has been evidence of students' low performance in mathematics as a result of their inadequate understanding of mathematical concepts. Recently, several countries including Finland have reformed their mathematics curricula towards conceptual understanding rather than relying only on algorithms. Based on the work of Piaget, Bruner, and Montessori as well as previous research, when manipulatives (i.e. hands-on learning materials) are used appropriately and effectively, they can assist students in developing their understanding of mathematical concepts through multimodality and experiential learning.

My doctoral research empirically examines how to benefit from manipulatives in a context of primary school classrooms for equation concepts understanding. Mixed-methods research was conducted to compare class interventions using manipulatives with interventions without. Four class teachers (3<sup>rd</sup>-6<sup>th</sup> grades) and 74 students (ages 9–12) from a primary school in southern Finland participated in the study. Data collection methods consisted of 1) teachers' pre- and post-interviews, 2) class intervention observations, including one control group (a multimodal class without manipulatives) and two treatment groups (a multimodal class with a physical or virtual manipulative), and 3) students' post-tests and self-evaluations.

The research findings point to the benefits of manipulatives in multimodal mathematics classrooms. Based on the data collected by all the methods, the physical manipulative-based class interventions are most likely to assist students in developing their equation concepts understanding. The implication from the research supports previous studies that using manipulatives together with linking concrete representations built via the manipulatives and abstract mathematical symbols of mathematical concepts appear to assist students in developing their conceptual understanding.

*Keywords: conceptual understanding, manipulatives, mathematics, multimodality, primary school*

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# **Risk management in the airline industry: Are operational and financial hedging substitutes or complements?**

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## **Abstract**

Several types of risk can affect the functioning and earnings of airlines. As the customers of airlines with international destinations are around the world, the income of airlines can be in various currencies, causing the airlines to face currency risk. Like any firms, airline companies are exposed to changes in their borrowing cost and input prices. The volatility of exchange rates, interest rates and fuel prices can lead to financial instability. It thus becomes an issue of absolute necessity for airlines to manage their risk to prevent the adverse effect of such changes.

While existing studies focuses on diversified fleet and the usage of fuel derivatives, this paper conducts a more comprehensive research. The paper aims to find the factors determining the use of operational and financial hedging in the airline industry and how risk management strategies can affect the profitability and leverage of airlines. Employing a method of Kim et al., we introduce a destination diversity index as an operation hedging indicator and calculate the fleet diversity index following the method introduced by Berghöfer and Lucey. With regard to financial hedging, we identify the factors associated with the airline's use of financial derivatives and examine whether operational hedging policy is a substitute for or a complement to financial derivative usage.

Our results indicate that fleet diversification is a complement to using currency and fuel derivatives while destination diversification is a substitute for using currency derivative. Moreover, larger airlines use more various types of derivatives, but the effect of firm size on financial derivatives usages depends on the type of risk considered. Further, state-owned airlines do not use derivatives as much as private airlines. Finally, we find an evidence of moral hazard behaviour of the airlines and the effects of the characteristics and governance on risk management and financial performance.

**Keywords:** *Risk management; financial derivatives, operational hedging; corporate governance*

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# **Financial Access for the Poor and Small Businesses in Thailand**

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## **Abstract**

This paper uses the survey data collected from 3,011 individuals in the low-income provinces of Thailand to investigate how households choose a financial service provider for either saving or borrowing. Individuals in the survey, which was conducted by the Thai Fiscal Policy Office, may or may not own businesses. Here, there are two classifications of small businesses: agricultural business owners (e.g. farmers) and other business owners (e.g. shop owners). Small businesses and households in the rural area can borrow from commercial or state-owned banks, semi-formal providers (e.g. co-operatives, saving groups or village funds), or their own relatives.

In the investigation, a wide range of factors is included: i) business obstacles (e.g. insufficient capital, experience and financial literacy), ii) demographic factors (e.g. gender and education), iii) types of businesses, and iv) issues of concerns (e.g. the flexibility of repayment, the quality of services, the ease of financial access). The result of logistic regressions show that these factors can explain the preference for particular providers over the others. State-owned banks, village funds, and savings groups features the main providers of saving services, whereas the roles of commercial banks and cooperatives are still limited in this regard. With regard to borrowing, agricultural business owners tend to borrow from state-owned banks, cooperatives, and village funds while the owners of other businesses tend to borrow from commercial banks. The findings therefore shed light the role of microfinance in promoting financial access for the poor and small businesses in Thailand.

The paper offers useful insights from a policy perspective of i) the formal and semi-formal financial service providers' role in providing fund and other financial services for small businesses and ii) the obstacles as well as factors affecting the individuals' preference for particular financial service providers. Such an understanding would raise awareness about the small businesses' difficulties in accessing financial services and the importance of semi-formal financial service providers in improving financial access for the poor and small businesses in Thailand. As a result, it should be of interest to academics, bankers as well as policy makers.

*Keywords: financial access, preference, poor households, small businesses, non-bank financial institutions*

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