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Judul Artikel : Stock Price Modeling Using Localized Multiple Kernel Learning Support Vector Machine

Nama Jurnal : ICIC Express Letters Part B: Applications

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Hasbi Yasin <hasbiyasin17@gmail.com>

Fwd: Submission Confirmation (ICICIC2019-163)

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Rezzy Eko Caraka <rezzyekocaraka@gmail.com> Fri, Aug 14, 2020 at 7:53 PM
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Dear Mr. REZZY EKO CARAKA,

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Reference No.: ICICIC2019-163
Title: Stock Price Modeling using Localized Multiple Kernel Learning Support Vector Machine
Author(s): HASBI YASIN, REZZY EKO CARAKA, abdul hoyyi and sugito sugito

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Professor, Center for Liberal Arts, Tokai University
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Tel.: 81-96-386-2666, Fax: 81-96-386-2666
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Acceptance Letter: ICICIC2019-163

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Dear Mr. HASBI YASIN,

We are pleased to let you know that your paper submitted to ICICIC2019 below

Reference No.: ICICIC2019-163

Title: Stock Price Modeling using Localized Multiple Kernel Learning Support Vector Machine

Author(s): HASBI YASIN, REZZY EKO CARAKA, abdul hoyyi and sugito sugito

has been accepted for oral presentation in the 14th International Conference on Innovative Computing, Information and Control (ICICIC2019), to be held in Seoul, Korea, August 26-29, 2019.

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1) The last keyword of “localized” is not proper. “Localized Multiple Kernel Learning Support Vector Machine” or “LMKL-SVM” can be selected as one keyword.
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Please feel free to contact us at icicic2019@icicconference.org if you have any questions.

Kind regards,

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Program and Steering Committee Chair, ICICIC2019
Professor, Center for Liberal Arts, Tokai University
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Dear Dr.Yan SHI,
Thank you for your email
Could you send me an official letter ICICIC2019-163?
Please address **Mr. Hasbi Yasin, Department of Statistics, Diponegoro University, Indonesia** as **presenter.**
Thank you very much and see you soon in Korea.

Thank you

Warmly,
Rezzy Eko Caraka
www.rezzyekocaraka.com
M317, College of Informatics Chaoyang University of Technology
168, Jifong East Road, Wufong Dist., Taichung City 41349, Taiwan (R.O.C.)
Phone: +886-4-2332-3000 #4463, Fax: +886-4-2374-2337
"I always Love to analyze, interpret and take a conclusion from the data. From that, I can make the decision and show the fact" - Rezzy Eko Caraka

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Yan Shi <yshi@ktmail.tokai-u.jp> Wed, Jul 10, 2019 at 2:22 PM
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Dear Dr. Rezzy Eko Caraka,

We will send it to you, after you completed Registration with Fee.

Kind regards,

Yan SHI

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Kind regards, and we are looking forward to seeing you in Seoul.

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Dr. Yan SHI
Program and Steering Committee Chair, ICICIC2019
Professor, Center for Liberal Arts, Tokai University
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Dear Dr.Yan SHI,
Thank you for your email.
Please send me official LoA as soon as possible and note Mr.Hasbi Yasin as presenter.

Thank you

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Thank you

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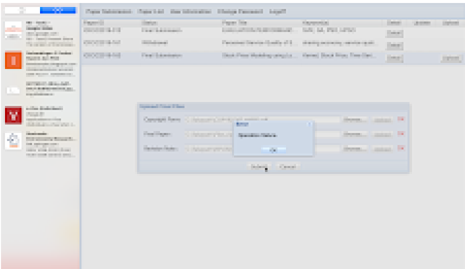

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Paper ID: ICICIC2019-163 Prof. ☐ / Dr. ☐ / Mr. **V** / Ms. ☐

First name: **HASBI** ____________Family name: **YASIN**

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Institution: **DIPONEGORO UNIVERSITY**

Mailing address: **JL.Prof.H.Soedarto S.H, Tembalang, Kec. Tembalang, Kota Semarang, Jawa Tengah 50275, Indonesia**

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Reference No.: ICICIC2019-163

Title: STOCK PRICE MODELING USING LOCALIZED MULTIPLE KERNEL LEARNING SUPPORT VECTOR MACHINE

Author(s): HASBI YASIN, REZZY EKO CARAKA, ABDUL HOYYI, SUGITO

NO	REVIEWER	ANSWER
1.	The last keyword of “localized” is not proper. “Localized Multiple Kernel Learning Support Vector Machine” or “LMKL-SVM” can be selected as one keyword.	We already revised based on reviewer suggestion and modify the keyword
2.	What leads to the current study, that is, the study motivation, should be explicitly clarified	The motivation of this research already discuss in last paragraph of introduction section. We combined different type of optimization to get best parameter in LMKL-SVM
3.	In the last sentence of the Abstract, should “LKMSVM” be “LMKL-SVM”?	We change to LMKL-SVM

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Part B: Applications
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STOCK PRICE MODELING USING LOCALIZED MULTIPLE KERNEL LEARNING SUPPORT VECTOR MACHINE

Hasbi Yasin[1], Rezzy Eko Caraka[2], Abdul Hoyyi[1], Sugito[1]
[1]Department of Statistics, Diponegoro University, Semarang, Central Java, Indonesia
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Received Juny 2019; accepted November 2019

ABSTRACT. *Effectively and efficiently learning an optimal kernel is of great importance to the success of kernel method. Along with this line of research, many pioneering kernel learning algorithms have been proposed, developed and combined in many ways. This paper aims to explain the application of Localized Multiple Kernel Learning Support Vector Machine (LMKL-SVM) to predict the daily stock price of PT. XL Axiata Tbk (EXCL), PT. Indofood Sukses Makmur Tbk (INDF) and PT. Unilever Indonesia Tbk (UNVR) from January 2014 to May 2016. It can be concluded that LMKL-SVM has good performance to predict daily stock price with Mean Absolute Percentage Error (MAPE) produced all less than 2%.*

Keywords: Stock price, Multi Kernel, Localized SVM, Time Series.

1. **Introduction.** The area of data mining and machine learning deals with the design of methods that can learn rules from data [1], adapt to changes, and improve performance with experience [2]. Also, to be one of the initial dreams of robust, efficient and applicable methods and reached minimum error, machine learning has become crucial to solve increasingly complex problems and become more integrated into many application, precisely time series [3][4]. Machine learning theory also has close connections to issues in Economics[5][6][7]. Machine learning methods can be used in the design of auctions and other pricing mechanisms with guarantees on their performance[8]. Risk is the result of probabilistic world where there are no certainties and complexities abound. People use statistics to mitigate risk in decision making. Reliable knowledge about future can help investor make the right decision[9] with lower levels of risk [10]. Figure 1 represent as a statistician we must have abilities to capture of data and make visualization to catch and present the insight with accurately reflect the numbers and inappropriate visuals can create misinterpretation and misunderstanding. Using relevant methods with error minimum and could be the detection of pattern in the data to gain knowledge and make argument, interpretation and justification[11]. Support vector machines have become a subject of intensive study [12]. Many authors combine and enhanced this methods in time series[13], regression[14], classification and cluster. In this case, we can compute a string kernel from the sequence data and a Gaussian kernel

upon the vectorial data, and learn the relative significance of the two kernels via the setting of multiple kernel learning. By multiple kernel learning[15], the relative importance of the kernels can be evaluated together with the solution of the support vectors (SVR)[16]. Recently, multiple kernel learning has been automated for support vector machine (SVM) classification using semidefinite programming (SDP) in optimization theory. However, the problem of multiple kernel learning on SV regression has not yet been examined. In this work, we formulate the SV regression problem as SMO[17], quadratic programming (QP)[18], and MOSEK optimization problems[19], so that kernel selection can be performed automatically for SV regression. In this paper we use support vector machines in the field of time series prediction. Brief introduction to support vector regression (SVR) and adaptive machine learning algorithms can be viewed as a model for how individuals can or should adjust to change environment [20]. Moreover, the development of especially fast-adapting algorithms sheds light on how approximate equilibrium states might quickly be reached in a system, even when each individual has a large number of different possible choices. In the other direction, economic issues arise in Machine Learning when not only is the computer algorithm adapting to its environment, but it also is affecting its environment and the behavior of other individuals in it as well [21]. Connections between these two areas have become increasingly strong in recent years as both communities aim to develop tools for modeling. The remainder of the paper is organized as follows. Section 2 provides a review of the material and methods. Section 3 presents dicussion. Finally, conclusions and future research directions are indicated in Section 4.

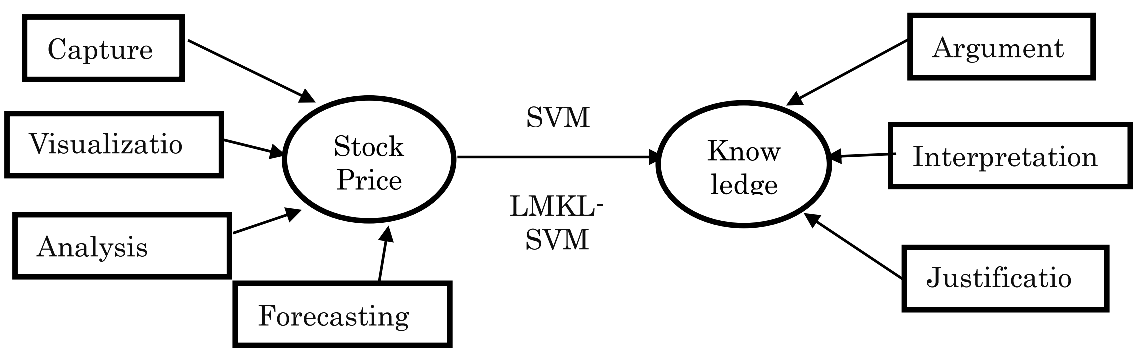


FIGURE 1. An Illustration of Stock Price analysis using LMKL-SVM.

2. **Methods.** Support Vector Regression (SVR) is part of Support Vector Machine (SVM) for regression case. SVR is also a method that can overcome the overfitting, so it will produce a good performance. Suppose there are l training data, $(\mathbf{x}_i, y_i)$ $i = 1, \dots, l$ of the input data $\mathbf{x} = \{\mathbf{x}_1, \dots, \mathbf{x}_l\} \subseteq \Re^N$ and $\mathbf{y} = \{y_1, \dots, y_l\} \subseteq \Re$. SVR obtained by the method of regression function as follows:

$$f(\mathbf{x}) = \mathbf{w}^T \varphi(\mathbf{x}) + b \quad (1)$$

With:

$\mathbf{w}$ = vector of weight coefficient

$\varphi(\mathbf{x})$ = feature space

b = bias

In order to obtain good generalization for the regression function, can be done by minimizing the norm of **w**. Hence the need for the completion of the following optimization problem:

$$\min\{\frac{1}{2}\|\mathbf{w}\|^2\} \tag{2}$$

with the provision of:

$$\begin{aligned} y_i - \mathbf{w}^T\varphi(\mathbf{x}_i) - b &\le \varepsilon \\ \mathbf{w}^T\varphi(\mathbf{x}_i) - y_i + b &\le \varepsilon, i = 1, 2, \dots, l \end{aligned} \tag{3}$$

The loss function shows the relationship between an error and the subject penalties. Differences loss SVR function will produce different formulations[22]. There are two types of loss function used in this study, the ε-insensitive and quadratic loss function. Here is a mathematical formulation for the ε-insensitive loss function:

$$L(\mathbf{y}, f(\mathbf{x})) = \begin{cases} o, & \text{for } |f(\mathbf{x}) - \mathbf{y}| < \varepsilon \\ |f(\mathbf{x}) - \mathbf{y}| - \varepsilon, & \text{otherwise} \end{cases} \tag{4}$$

The solution provided is:

$$\max\{-\frac{1}{2}\sum_{i=1}^{l}\sum_{j=1}^{l}(\alpha_i - \alpha_i^*)(\alpha_j - \alpha_j^*) < \mathbf{x}_i, \mathbf{x}_j > + \sum_{i=1}^{l}\alpha_i(y_i - \varepsilon) - \alpha_i^*(y_i + \varepsilon)\} \tag{5}$$

or can be simplified into:

$$\max\{-\frac{1}{2}\sum_{i=1}^{l}\sum_{j=1}^{l}\beta_i\beta_j < \mathbf{x}_i, \mathbf{x}_j > - \sum_{i=1}^{l}\beta_i y_i\} \tag{6}$$

with the provision of:

$$\begin{aligned} -C \le \beta_i \le C, i = 1, \dots, l \\ \sum_{i=1}^{l}\beta_i = 0 \end{aligned} \tag{7}$$

where $\beta_i = \alpha_i - \alpha_i^*$, $\beta_j = \alpha_j - \alpha_j^*$, $j = 1, 2, \dots, l$, and C is a parameter which gives a tradeoff between model complexity and training error.

While the quadratic loss function:

$$L(\mathbf{y}, f(\mathbf{x})) = (f(\mathbf{x}) - \mathbf{y})^2 \tag{8}$$

Produce a solution:

$$\max\{-\frac{1}{2}\sum_{i=1}^{l}\sum_{j=1}^{l}(\alpha_i - \alpha_i^*)(\alpha_j - \alpha_j^*) < \mathbf{x}_i, \mathbf{x}_j > + \sum_{i=1}^{l}(\alpha_i - \alpha_i^*)y_i - \frac{1}{2C}\sum_{i=1}^{l}(\alpha_i^2 + \alpha_i^{*2})\} \tag{9}$$

or can be simplified into:

$$\max\{-\frac{1}{2}\sum_{i=1}^{l}\sum_{j=1}^{l}\beta_i\beta_j < \mathbf{x}_i, \mathbf{x}_j > + \sum_{i=1}^{l}\beta_i y_i - \frac{1}{2C}\sum_{i=1}^{l}\beta_i^2\} \tag{10}$$

with the provision of:

$$\sum_{i=1}^{l}\beta_i = 0 \tag{11}$$

One method that can be used to optimize the hyperplane, which is to solve the quadratic programming with constraints set is Sequential Minimal Optimization (SMO). Sequential Minimal Optimization (SMO) algorithm to solve the problem Quadratic Programming (QP) that arise during training on Support Vector Machine. SMO is a simple algorithm that can solve the problem QP quickly on SVM. SMO algorithm to solve the problems in the SVM-QP without using optimization measures QP numerically [23]. Instead, SMO chooses to resolve the smallest possible optimization problem involves two elements α_i the need to meet the limiting linear equations. Many decision problems facing individuals and companies can be cast as an optimization problem i.e. making an optimal decision given some constraints specifying the possible decisions. As an example consider the problem of determining an optimal production plan. This can be formulated as maximizing a profit function given a set of constraints specifying the possible production plans. The advantage of MOSEK: (i) solve linear optimization problems using either an interior-point or a simplex optimizer, (ii) Solve conic quadratic and semi definite optimization problems, (iii) Solve convex quadratic optimization problems, (iv) Handle convex quadratic constraints, (v) Solve mixed-integer optimization problems, including linear, convex quadratic and conic quadratic problems, (vi) Solve linear least squares problems with linear constraints.

3.Discussion. In this research, we use the SVR with some of kernel functions simultaneously as called Multiple Kernel Support Vector Regresion (MKL-SVR). MKL-SVR is one model that can capture the nonlinear pattern of financial time series data including data on stock returns. Research on MKL-SVR has developed rapidly. The model is based on modeling SVR by Vapnik [24] using some kernel functions simultaneously. MKL-SVR modeling is the development of models SVR which involves some kernel functions, both with the same type or different. Specifically, Gönen and Alpaydin [25] developed a method Localized Multiple Kernel Support Vector Regression (LMKL-SVR) as a part of Localized Multiple Kernel Support Vector Machine (LMKL-SVM) for regression case. Two Reasons for Using a Kernel [26]:

1. Turn a linear learner into a non-linear learner (e.g. RBF, polynomial, sigmoid)
2. Make non-vectorial data accessible to learner (e.g. string kernels for sequences)

Localized kernel regression (LKR) is a multidimensional extension of kernel regression that uses a matrix of bandwidth parameters optimally selected for each input dimension instead of a single bandwidth parameter [27]. The problem of automatically selecting a set of optimal bandwidth parameters is an area of active research and one for which there is no clear solution. The main advantage of LMKL over canonical multiple kernel machines is the inherent regularization effect of the gating model[28]. Canonical methods learn sparse models as a result of regularization on the weight vector but the underlying complexity of the kernel function is the main factor for determining the model complexity. MKL can combine only different kernel functions and more complex kernels are favored over the simpler ones in order to get better performance. However, LMKL can also combine multiple copies of the same kernel

$$f_{\mathcal{R}}(x) = \sum_{m=1}^{p} \eta_m(\boldsymbol{x}|\mathbf{V}) \langle \omega_m, \phi_m(x) \rangle + b \qquad (12)$$

And the optimization of the equation

$$\min . \frac{1}{2} \sum_{m=1}^{P} \|\boldsymbol{\omega}_m\|_2^2 + C \sum_{t=1}^{N} (\xi_i^+ + \xi_i^-) \qquad (13)$$

$$\text{w.r.t. } \boldsymbol{\omega}_m \xi_i^+, \xi_i^-, \mathrm{V}$$

$$\text{s.t } \epsilon + \xi_i^+ \geq y_i - f_{\mathcal{R}}(x_i) \quad \forall_i$$

$$\epsilon + \xi_i^- \geq f_{\mathcal{R}}(x_i) \quad \forall_i$$

$$\xi_i^+ \geq 0 \quad \forall_i \; ; \; \xi_i^- \geq 0 \quad \forall_i$$

Where C is a regularization parameter with ξ_i^+, ξ_i^- is the vector of slack variable and ϵ is the tube width. Optimization of the slack variable is not convex and nonlinear. By adding V will get a convex optimization, and we can get a dual formulation:

$$\max . \mathrm{J}(\mathbf{V}) = \sum_{t=1}^{N} y_i(\alpha_i^+ - \alpha_i^-) - \epsilon \sum_{i=1}^{N} (\alpha_i^+ - \alpha_i^-) - \frac{1}{2} \sum_{t=1}^{N} \sum_{j=1}^{N} (\alpha_i^+ - \alpha_i^-)(\alpha_j^+ - \alpha_j^-) k_\eta(x_i, x_j) \qquad (14)$$

$$\text{w.r.t. } \alpha_j^+, \alpha_j^-; \; \text{s.t} \sum_{t=1}^{N} (\alpha_i^+ - \alpha_i^-) = 0; \; C \geq \alpha_i^+ \geq 0 \; \forall_i; \text{ and } C \geq \alpha_i^- \geq 0 \; \forall_i.$$

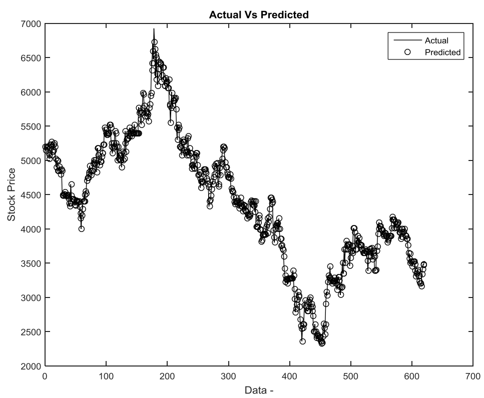
Locally combined kernel function can be defined as

$$k_\eta(x_i, x_j) = \sum_{m=1}^{P} \eta_m(x_i|\mathrm{V}) k_m(x_i, x_j) \eta_m(x_j|\mathrm{V}) \qquad (15)$$

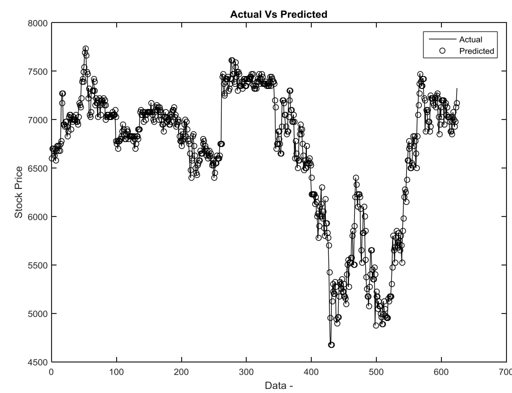
In order to get the function as follows

$$f_{\mathcal{R}}(x) = \sum_{t=1}^{N} (\alpha_i^+ - \alpha_i^-) k_\eta(x_i, x_j) + b.$$

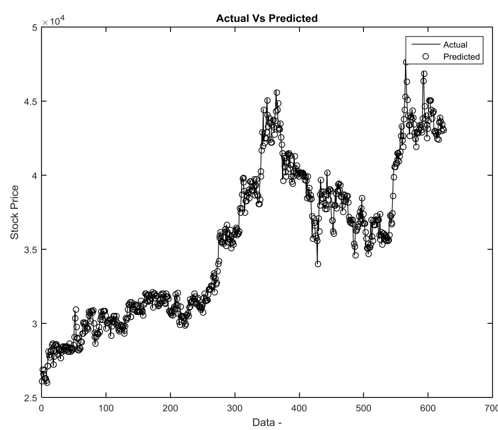
In this paper we used the optimization algorithm using MOSEK, SMO, QP. On data stock prices of PT. EXCL, PT.INDF and PT UNVR. The data used are the daily stock price from January 2014 to May 2016. We using locally linear kernel and quadratic kernel. Then, we used parameter C= 10,25,50,75,100 also tube width (e) 0.5. We can see the plot of prediction vs actual on Fig.3 illustrates a good to fit (indicated by blue and red line). The size of the error used in this study is the value of Mean Absolute Percentage Error (MAPE) and Root of Mean Squared Error (RMSE), so the formula of MAPE and RMSE can be expressed as: MAPE= $\left(\sum_{i=1}^{n} \frac{|yi-\widehat{yi}|}{yi}\right) x\ 100$ and RMSE= $\sqrt{\sum_{i=1}^{n} \frac{(yi-\widehat{yi})^2}{n}}$. Result of simulation LMKL-SVM can be seen in Table 1.



(a)



(b)



(c)

FIGURE 2. Plot prediction vs actual EXCL (A), INDF (B), UNVR (C)

According to the Table 1, we can see that the regularization parameters, tube width, and the type of optimization affect the learning process of LMKL-SVM. In this study, we only use two types of kernel locality, such as linear and quadratic. As a result of the simulation and analysis using LMKL-SVM. The best optimization in EXCL stock price is QP with *C*=100 and *E*=0.5. Then the best optimization in INDF stock prices MOSEK with *C*=50 and *E*=0.5. Also, the best optimization in UNVR stock price is SMO with *C* = 100, and *E*= 0.5.

TABLE 1. Simulation using LMKL-SVM

STOCK	N	*C*	*E*	Optimization	MAPE (%)	RMSE
EXCL	621	100	0.5	SMO	1.87	112.6482
		100*	0.5*	QP*	1.87*	112.6312*
		75	0.5	SMO	1.88	113.1074
		50	0.5	MOSEK	1.89	114.8227
		10	0.5	SMO	1.91	113.7411
		25	0.5	SMO	1.87	112.7068
INDF	625	100	0.5	SMO	1.28	120.7054
		100	0.5	QP	1.28	120.7054
		75	0.5	SMO	1.28	120.7344
		50*	0.5*	MOSEK*	1.28*	120.6186*
		10	0.5	SMO	1.45	142.8360
		25	0.5	SMO	1.28	120.7866
UNVR	625	100*	0.5*	SMO*	1.25*	638.0822*
		100	0.5	QP	1.25	648.0822
		75	0.5	SMO	1.25	648.9264
		50	0.5	MOSEK	1.27	651.7972
		10	0.5	SMO	1.87	355504.2368
		25	0.5	SMO	1.37	693.7725

4. Conclusions. Based on the analysis concludes that LMKL-SVM had a very good performance in modeling with MAPE less than 2%. In this paper, we managed to make matlab GUI to simplify calculations and simulations using three different optimizations and also different kernel. Localized multiple kernel also known as lazy learning (LL) is a non-parametric. In a nutshell, localized multiple kernel SVR methods are more powerful than parametric methods if the assumptions for the parametric model cannot be met. The advantage of this method can be used to get a quick prediction with little error and easily implemented in the era of big data. Future studies will consider the feature selection and run the ensemble model with metaheuristic optimization.

Acknowledgment. This research fully supported by Institute for Research and Community Services (LPPM) Diponegoro University, under contract 329-44/UN7.P4.3/PP/2019.

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Int. J. Innov. Comput. Inf. Control, vol. 14, no. 2, pp. 629–645, 2018.
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Cc: icicic2019 <icicic2019@icicconference.org>, Hasbi Yasin <hasbiyasin17@gmail.com>

Dear Dr. Rezzy Eko Caraka,

The final submission of your paper (ICICIC2019-163) has been received. Thank you.

Kind regards, and we are looking forward to meeting you in Seoul, soon.

Ms. Fang Wang

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Tel. & Fax: +81-96-386-2666
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To:icicic2019 <icicic2019@icicconference.org>; Yan Shi <yshi@ktmail.tokai-u.jp>; Hasbi Yasin <hasbiyasin17@gmail.com>; Fang Wang <fangwang@icicconference.org>
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Confirmation about article ICICIC 2019

3 messages

Hasbi Yasin <hasbiyasin@live.undip.ac.id> Tue, Nov 5, 2019 at 7:12 AM
To: icicic2019@icicconference.org

Dear Dr.Yan Shi,

I have submitted my manuscript titled Stock Price Modeling using Localized Multiple Kernel Learning Support Vector Machine [manuscript id: **ICICIC2019-163**] to ICICIC2019. I would be grateful if you could let me know whether there has been any further progress on my submission.

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Dear Mr. Hasbi Yasin,

Thank you again for your contribution to ICICIC2019.

Your paper will be recommanded to published in ICIC-ELB if it is satisfy.

Kind regards,

Ms. Fang Wang

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Program & Steering Committee Chair, ICICIC2019
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Unsatisfactory Final Submission (ICICIC2019-163)

1 message

icicic2019 <icicic2019@icicconference.org> Wed, Nov 6, 2019 at 4:18 PM
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To: rezzyekocaraka <rezzyekocaraka@gmail.com>
Cc: hasbiyasin <hasbiyasin@live.undip.ac.id>

Dear Dr. Rezzy Eko Caraka,

We have got the documents for the final submission. However, some problems still exist.

Further improvements on the final version of your manuscript are needed, especially the following points.

1) Introduction is found not properly done, in which too much background information on machine learning has been talked about, no logic exists when literature is reviewed and research aims, contributions and innovations are not stated clearly.
2) The explanation of Figure 1 on Page 1 is not easy to understand. In Figure 1, "interpretatio" should be "interpretation". Please make this figure complete.
3) This manuscript is not organized well. The proposed localized multiple kernel learning support vector machine is partially introduced in Section 3, "Application".
4) "LMKL-SVM" is claimed as the proposed method for stock price prediction. However, in the end of Page 5, "Result of simulation LMKSVR can be seen in Table 1" is stated. What is the relationship between LMKSVR and LMKL-SVM? In Figure 3, LMKSVR is also used. Do "QP" and "QUADPROG" refer to the same?
5) In the end of Page 5, "so the formula of MAPE and RMSE can be expressed as..." is stated, but in its following part, only MAPE formula is shown. How to calculate RMSE?
6) Some variables like "j" in Equation (5) and "C" in Equation (7) are not defined at the first use in the manuscript. In the 3rd and 4th lines of Section 2, "l" is defined twice, which is not necessary. Equations in Section 3 are shown in a mess.
7) In the beginning of Section 3, the full form of LMKL-SVM is not right.
8) Considering monochrome print, it is hard to differentiate two curves shown in different colors in Figure 3. Please choose another display alternative.
9) There exist lots of composition and grammar errors in the manuscript which limit its readability. For example, the 2nd last sentence on Page 1 is structurally wrong. The 2nd sentence on Page 3 is also a typical ill-formed statement. Please refer to a professional to thoroughly check the English presentation of the whole manuscript.
10) It is expected to include potential future research direction in Conclusion.
11) In Reference [2], no enough source information is provided. Related work, like "The Plasticity and Elasticity of Stock Price Variations - Part 2: Model Analysis and Application" by Xuefeng Wang, in International Journal of Innovative Computing, Information and Control, vol.14, no.2, pp.629-645, 2018, is suggested to be referred to.

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Warmly,
Rezzy Eko Caraka
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PhD Student in College of Informatics Chaoyang University of Technology (CYUT), Taiwan (ROC)
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"I always Love to analyze, interpret and take a conclusion from the data. From that, I can make the decision and show the fact" - Rezzy Eko Caraka

Further improvements on the final version of your manuscript are needed, especially the following points.

1) Introduction is found not properly done, in which too much background information on machine learning has been talked about, no logic exists when literature is reviewed and research aims, contributions and innovations are not stated clearly.

Answer:

We already put the research aims:

In this case, we can compute a string kernel from the sequence data and a Gaussian kernel upon the vectorial data, and learn the relative significance of the two kernels via the setting of multiple kernel learning

The remainder of the paper is organized as follows. Section 2 provides a review of the material and methods. Section 3 presents our application. Finally, conclusions and future research directions are indicated in Section 4.

2) The explanation of Figure 1 on Page 1 is not easy to understand. In Figure 1, “interpretatio” should be “interpretation”. Please make this figure complete.

Answer:

We already modify Fig 1

3) This manuscript is not organized well. The proposed localized multiple kernel learning support vector machine is partially introduced in Section 3, “Application”.

Answer:

We already revised the section 3 to discussion

4) “LMKL-SVM” is claimed as the proposed method for stock price prediction. However, in the end of Page 5, “Result of simulation LMKSVR can be seen in Table 1” is stated. What is the relationship between LMKSVR and LMKL-SVM? In Figure 3, LMKSVR is also used. Do “QP” and “QUADPROG” refer to the same?
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6) Some variables like “j” in Equation (5) and “C” in Equation (7) are not defined at the first use in the manuscript. In the 3rd and 4th lines of Section 2, “l” is defined twice, which is not necessary. Equations in Section 3 are shown in a mess.
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8) Considering monochrome print, it is hard to differentiate two curves shown in different colors in Figure 3. Please choose another display alternative.

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Answer:

We already modify the sentences:

Also, to be one of the initial dreams of robust, efficient and applicable methods and reached minimum error, machine learning has become crucial to solve increasingly complex problems and become more integrated into many application, precisely financial time series

The loss function shows the relationship between an error and the subject penalties

10) It is expected to include potential future research direction in Conclusion.

Future studies will consider the feature selection and run the ensemble model with metaheuristic optimization.

11) In Reference [2], no enough source information is provided. Related work, like "The Plasticity and Elasticity of Stock Price Variations - Part 2: Model Analysis and Application" by Xuefeng Wang, in International Journal of Innovative Computing, Information and Control, vol.14, no.2, pp.629-645, 2018, is suggested to be referred to.

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S. Sra, S. Nowozin, and S. J. Wright, *Optimization for Machine Learning*. MIT Press, 2019.

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Your paper has been accepted for the publication in ICIC Express Letters, Part B: Applications: http://www.icicelb.org/

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Kind regards,

Ms. Fang Wang

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STOCK PRICE MODELING USING LOCALIZED MULTIPLE KERNEL LEARNING SUPPORT VECTOR MACHINE

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Abstract. *Effectively and efficiently learning an optimal kernel is of great importance to the success of kernel method. Along with this line of research, many pioneering kernel learning algorithms have been proposed, developed and combined in many ways. This paper aims to explain the application of Localized Multiple Kernel Learning Support Vector Machine (LMKL-SVM) to predict the daily stock price of PT.XL Axiata Tbk (EXCL), PT.Indofood SuksesMakmur Tbk (INDF) and PT.Unilever Indonesia Tbk (UNVR) from January 2014 to May 2016. It can be concluded that LMKL-SVM has good performance to predict daily stock price with Mean Absolute Percentage Error (MAPE) produced all less than 2%.*

Keywords: Stock price, Multi kernel, Localized SVM, Time series

1. **Introduction.** The area of data mining and machine learning deals with the design of methods that can learn rules from data [1], adapt to changes, and improve performance with experience [2]. Also, to be one of the initial dreams of robust, efficient and applicable methods and reached minimum error, machine learning has become crucial to solve increasingly complex problems and become more integrated into many applications, precisely time series [3,4]. Machine learning theory also has close connections to issues in Economics [5-7]. Machine learning methods can be used in the design of auctions and other pricing mechanisms with guarantees on their performance [8]. Risk is the result of probabilistic world where there are no certainties and complexities abound. People use statistics to mitigate risk in decision making. Reliable knowledge about future can help investor make the right decision [9] with lower levels of risk [10]. Figure 1 represented as a statistician we must have abilities to capture data and make visualization to catch and present the insight with accurately reflecting the numbers and inappropriate visuals can create misinterpretation and misunderstanding. Using relevant methods with error minimum it could be the detection of pattern in the data to gain knowledge and make argument, interpretation and justification [11]. Support vector machines have become a subject of intensive study [12]. Many authors combine and enhance this method in time series [13], regression [14], classification and cluster. In this case, we can compute a string kernel from the sequence data and a Gaussian kernel upon the vectorial data, and learn the relative significance of the two kernels via the setting of multiple kernel learning. By multiple kernel learning [15], the relative importance of the kernels can be

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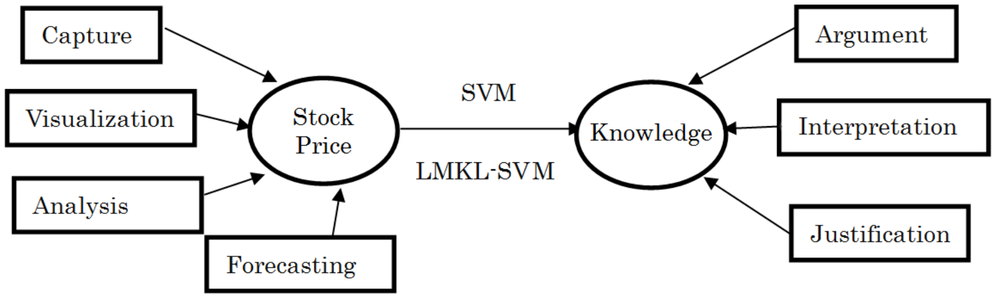

FIGURE 1. An illustration of stock price analysis using LMKL-SVM

evaluated together with the solution of the Support Vector Regression (SVR) [16]. Recently, multiple kernel learning has been automated for Support Vector Machine (SVM) classification using Semi Definite Programming (SDP) in optimization theory. However, the problem of multiple kernel learning on SV regression has not yet been examined. In this work, we formulate the SV regression problem as SMO [17], Quadratic Programming (QP) [18], and MOSEK optimization problems [19], so that kernel selection can be performed automatically for SV regression. In this paper we use support vector machines in the field of time series prediction. Brief introduction to Support Vector Regression (SVR) and adaptive machine learning algorithms can be viewed as a model for how individuals can or should adjust to change environment [20]. Moreover, the development of especially fast-adapting algorithms sheds light on how approximate equilibrium states might quickly be reached in a system, even when each individual has a large number of different possible choices. In the other direction, economic issues arise in machine learning when not only is the computer algorithm adapting to its environment, but it also is affecting its environment and the behavior of other individuals in it [21]. Connections between these two areas have become increasingly strong in recent years as both communities aim to develop tools for modeling. The remainder of the paper is organized as follows. Section 2 provides a review of the material and methods. Section 3 presents dicussion. Finally, conclusions and future research directions are indicated in Section 4.

2. **Methods.** Support Vector Regression (SVR) is part of Support Vector Machine (SVM) for regression case. SVR is also a method that can overcome the overfitting, so it will produce a good performance. Suppose there are l training data, $(\boldsymbol{x}_i, y_i)$ $i = 1, \ldots, l$ of the input data $\boldsymbol{x} = \{\boldsymbol{x}_1, \ldots, \boldsymbol{x}_l\} \subseteq \Re^{\mathrm{N}}$ and $\boldsymbol{y} = \{y_1, \ldots, y_l\} \subseteq \Re$. SVR is obtained by the method of regression function as follows:

$$f(\boldsymbol{x}) = \boldsymbol{w}^{\mathrm{T}}\varphi(\boldsymbol{x}) + b \tag{1}$$

with $\boldsymbol{w}$ = vector of weight coefficient, $\varphi(\boldsymbol{x})$ = feature space, b = bias.

In order to obtain good generalization for the regression function, it can be done by minimizing the norm of $\boldsymbol{w}$. Hence there is need for the completion of the following optimization problem:

$$\min \left\{ \frac{1}{2} ||\boldsymbol{w}||^2 \right\} \tag{2}$$

with the provision of:

$$y_i - \boldsymbol{w}^{\mathrm{T}}\varphi(\boldsymbol{x}_i) - b \leq \varepsilon \tag{3}$$

$$\boldsymbol{w}^{\mathrm{T}}\varphi(\boldsymbol{x}_i) - y_i + b \leq \varepsilon, \quad i = 1, 2, \ldots, l$$

The loss function shows the relationship between an error and the subject penalties. Differences loss SVR function will produce different formulations [22]. There are two types of loss function used in this study, the ε-insensitive and quadratic loss function. Here is a mathematical formulation for the ε-insensitive loss function:

$$L(\boldsymbol{y}, f(\boldsymbol{x})) = \begin{cases} 0, & \text{for } |f(\boldsymbol{x}) - \boldsymbol{y}| < \varepsilon \\ |f(\boldsymbol{x}) - \boldsymbol{y}| - \varepsilon, & \text{otherwise} \end{cases} \tag{4}$$

The solution provided is:

$$\max\left\{-\frac{1}{2}\sum_{i=1}^{l}\sum_{j=1}^{l}\left(\alpha_i - \alpha_i^*\right)\left(\alpha_j - \alpha_j^*\right) < \boldsymbol{x}_i, \boldsymbol{x}_j > + \sum_{i=1}^{l}\alpha_i(y_i - \varepsilon) - \alpha_i^*(y_i + \varepsilon)\right\} \tag{5}$$

or can be simplified into:

$$\max\left\{-\frac{1}{2}\sum_{i=1}^{l}\sum_{j=1}^{l}\beta_i\beta_j < \boldsymbol{x}_i, \boldsymbol{x}_j > - \sum_{i=1}^{l}\beta_i y_i\right\} \tag{6}$$

with the provision of:

$$-C \leq \beta_i \leq C, \quad i = 1, \ldots, l \tag{7}$$

$$\sum_{i=1}^{l}\beta_i = 0$$

where $\beta_i = \alpha_i - \alpha_i^*$, $\beta_j = \alpha_j - \alpha_j^*$, $j = 1, 2, \ldots, l$, and C is a parameter which gives a tradeoff between model complexity and training error.

While the quadratic loss function is:

$$L(\boldsymbol{y}, f(\boldsymbol{x})) = (f(\boldsymbol{x}) - \boldsymbol{y})^2 \tag{8}$$

Produce a solution:

$$\max\left\{-\frac{1}{2}\sum_{i=1}^{l}\sum_{j=1}^{l}\left(\alpha_i - \alpha_i^*\right)\left(\alpha_j - \alpha_j^*\right) < \boldsymbol{x}_i, \boldsymbol{x}_j > + \sum_{i=1}^{l}\left(\alpha_i - \alpha_i^*\right) y_i \right.$$
$$\left. -\frac{1}{2C}\sum_{i=1}^{l}\left(\alpha_i^2 + \alpha_i^{*2}\right)\right\} \tag{9}$$

or can be simplified into:

$$\max\left\{-\frac{1}{2}\sum_{i=1}^{l}\sum_{j=1}^{l}\beta_i\beta_j < \boldsymbol{x}_i, \boldsymbol{x}_j > + \sum_{i=1}^{l}\beta_i y_i - \frac{1}{2C}\sum_{i=1}^{l}\beta_i^2\right\} \tag{10}$$

with the provision of:

$$\sum_{i=1}^{l}\beta_i = 0 \tag{11}$$

One method that can be used to optimize the hyperplane, which is to solve the quadratic programming with constraints set is Sequential Minimal Optimization (SMO). Sequential Minimal Optimization (SMO) algorithm is to solve the problem Quadratic Programming (QP) that arises during training on support vector machine. SMO is a simple algorithm that can solve the problem QP quickly on SVM. SMO algorithm is to solve the problems in the SVM-QP without using optimization measures QP numerically [23]. Instead, SMO chooses to resolve the smallest possible optimization problem involving two elements α_i the need to meet the limiting linear equations. Many decision problems facing individuals and companies can be cast as an optimization problem, i.e., making an optimal decision given some constraints specifying the possible decisions. As an example consider the problem of determining an optimal production plan. This can be formulated as maximizing a profit function given a set of constraints specifying the possible production plans. The advantages of MOSEK: (i) solve linear optimization problems using either an interior-point or a simplex optimizer, (ii) solve conic quadratic and semi definite optimization problems, (iii) solve convex quadratic optimization problems, (iv) handle convex quadratic constraints, (v) solve mixed-integer optimization problems, including linear, convex quadratic and conic quadratic problems, and (vi) solve linear least squares problems with linear constraints.

3. **Discussion.** In this research, we use the SVR with some of kernel functions simultaneously as called Multiple Kernel Learning Support Vector Regresion (MKL-SVR). MKL-SVR is one model that can capture the nonlinear pattern of financial time series data including data on stock returns. Research on MKL-SVR has developed rapidly. The model is based on modeling SVR by Cortes and Vapnik [24] using some kernel functions simultaneously. MKL-SVR modeling is the development of models SVR which involves some kernel functions, both with the same type or different. Specifically, Gönen and Alpaydın [25] developed a method Localized Multiple Kernel Learning Support Vector Regression (LMKL-SVR) as a part of Localized Multiple Kernel Learning Support Vector Machine (LMKL-SVM) for regression case. Two reasons for using a kernel [26]:

1) Turn a linear learner into a non-linear learner (e.g., RBF, polynomial, and sigmoid)
2) Make non-vectorial data accessible to learner (e.g., string kernels for sequences)

Localized Kernel Regression (LKR) is a multidimensional extension of kernel regression that uses a matrix of bandwidth parameters optimally selected for each input dimension instead of a single bandwidth parameter [27]. The problem of automatically selecting a set of optimal bandwidth parameters is an area of active research and one for which there is no clear solution. The main advantage of LMKL over canonical multiple kernel machines is the inherent regularization effect of the gating model [28]. Canonical methods learn sparse models as a result of regularization on the weight vector but the underlying complexity of the kernel function is the main factor for determining the model complexity. MKL can combine only different kernel functions and more complex kernels are favored over the simpler ones in order to get better performance. However, LMKL can also combine multiple copies of the same kernel

$$f_R(x) = \sum_{m=1}^{p} \eta_m(\boldsymbol{x}|\boldsymbol{V}) \langle \omega_m, \phi_m(x)\rangle + b \tag{12}$$

And the optimization of the equation

$$\begin{aligned} \min \quad & \frac{1}{2}\sum_{m=1}^{p} ||\boldsymbol{\omega}_m||_2^2 + C\sum_{t=1}^{N}\left(\xi_i^+ + \xi_i^-\right) \\ \text{w.r.t.} \quad & \boldsymbol{\omega}_m \xi_i^+, \quad \xi_i^-, \quad V \\ \text{s.t.} \quad & \epsilon + \xi_i^+ \geq y_i - f_R(x_i) \quad \forall i \\ & \epsilon + \xi_i^- \geq f_R(x_i) \quad \forall i \\ & \xi_i^+ \geq 0 \quad \forall i; \quad \xi_i^- \geq 0 \quad \forall i \end{aligned} \tag{13}$$

where C is a regularization parameter with ξ_i^+, ξ_i^- is the vector of slack variable and ϵ is the tube width. Optimization of the slack variable is not convex and nonlinear. By adding V we will get a convex optimization, and we can get a dual formulation:

$$\begin{aligned} \max \quad J(\boldsymbol{V}) = & \sum_{t=1}^{N} y_i\left(\alpha_i^+ - \alpha_i^-\right) - \epsilon\sum_{i=1}^{N}\left(\alpha_i^+ - \alpha_i^-\right) \\ & - \frac{1}{2}\sum_{t=1}^{N}\sum_{j=1}^{N}\left(\alpha_i^+ - \alpha_i^-\right)\left(\alpha_j^+ - \alpha_j^-\right) k_\eta(x_i, x_j) \end{aligned} \tag{14}$$

$$\text{w.r.t.} \quad \alpha_j^+, \quad \alpha_j^-$$

$$\text{s.t.} \quad \sum_{t=1}^{N} \left(\alpha_i^+ - \alpha_i^-\right) = 0$$
$$C \geq \alpha_i^+ \geq 0 \quad \forall i; \text{ and } C \geq \alpha_i^- \geq 0 \quad \forall i$$

Locally combined kernel function can be defined as

$$k_\eta(x_i, x_j) = \sum_{m=1}^{p} \eta_m(x_i|V) k_m(x_i, x_j) \eta_m(x_j|V) \tag{15}$$

in order to get the function as follows

$$f_R(x) = \sum_{t=1}^{N} \left(\alpha_i^+ - \alpha_i^-\right) k_\eta(x_i, x_j) + b$$

In this paper we used the optimization algorithm using MOSEK, SMO, QP. On data stock prices of PT.EXCL, PT.INDF and PT.UNVR. The data used are the daily stock price from January 2014 to May 2016. We use locally linear kernel and quadratic kernel. Then, we used parameter $C = 10, 25, 50, 75, 100$ also tube width (e) 0.5. We can see the plot of prediction vs actual in Figure 3 illustrates a good to fit (indicated by blue and red lines). The size of the error used in this study is the value of Mean Absolute

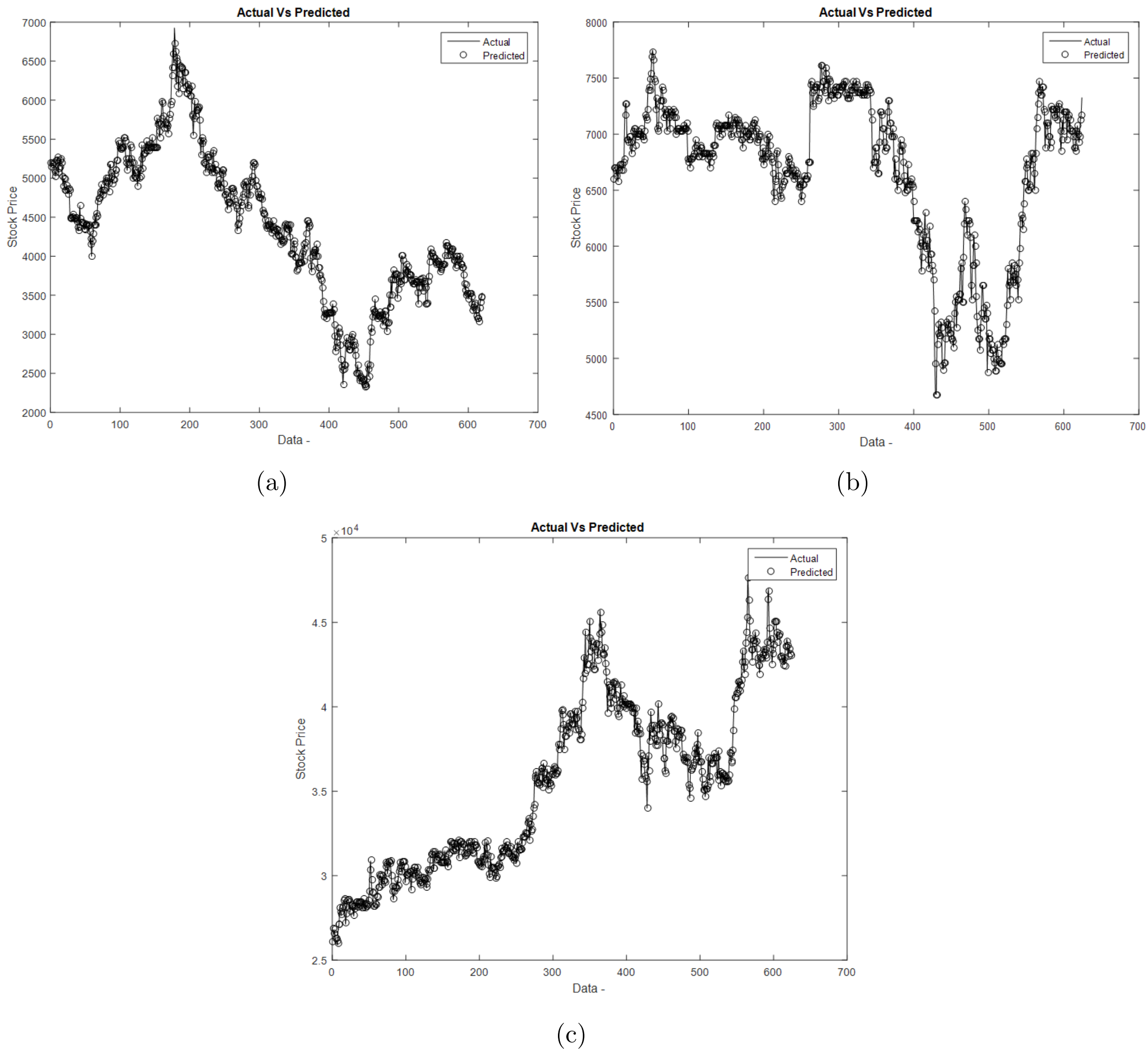

FIGURE 2. Plot prediction vs actual EXCL (a), INDF (b), UNVR (c)

TABLE 1. Simulation using LMKL-SVM

STOCK	N	C	E	Optimization	MAPE (%)	RMSE
EXCL	621	100	0.5	SMO	1.87	112.6482
		100*	0.5*	QP*	1.87*	112.6312*
		75	0.5	SMO	1.88	113.1074
		50	0.5	MOSEK	1.89	114.8227
		10	0.5	SMO	1.91	113.7411
		25	0.5	SMO	1.87	112.7068
INDF	625	100	0.5	SMO	1.28	120.7054
		100	0.5	QP	1.28	120.7054
		75	0.5	SMO	1.28	120.7344
		50*	0.5*	MOSEK*	1.28*	120.6186*
		10	0.5	SMO	1.45	142.8360
		25	0.5	SMO	1.28	120.7866
UNVR	625	100*	0.5*	SMO*	1.25*	638.0822*
		100	0.5	QP	1.25	648.0822
		75	0.5	SMO	1.25	648.9264
		50	0.5	MOSEK	1.27	651.7972
		10	0.5	SMO	1.87	355504.2368
		25	0.5	SMO	1.37	693.7725

Percentage Error (MAPE) and Root of Mean Squared Error (RMSE), so the formula of MAPE and RMSE can be expressed as: MAPE $= \left(\sum_{i=1}^{n} \frac{|yi - \widehat{yl}|}{yi}\right) \times 100$ and RMSE $= \sqrt{\sum_{i=1}^{n} \frac{(yi - \widehat{yl})^2}{n}}$. Result of simulation LMKL-SVM can be seen in Table 1.

According to Table 1, we can see that the regularization parameters, tube width, and the type of optimization affect the learning process of LMKL-SVM. In this study, we only use two types of kernel locality, that is linear and quadratic. As a result of the simulation and analysis using LMKL-SVM. The best optimization in EXCL stock price is QP with $C = 100$ and $E = 0.5$. Then the best optimization in INDF stock prices MOSEK with $C = 50$ and $E = 0.5$. Also, the best optimization in UNVR stock price is SMO with $C = 100$, and $E = 0.5$.

4. **Conclusions.** Based on the analysis it concludes that LMKL-SVM had a very good performance in modeling with MAPE less than 2%. In this paper, we managed to make matlab GUI to simplify calculations and simulations using three different optimizations and also different kernel. Localized multiple kernel also known as Lazy Learning (LL) is a non-parametric. In a nutshell, localized multiple kernel SVR methods are more powerful than parametric methods if the assumptions for the parametric model cannot be met. The advantage of this method can be used to get a quick prediction with little error and easily implemented in the era of big data. Future studies will consider the feature selection and run the ensemble model with metaheuristic optimization.

Acknowledgment. This research fully supported by Institute for Research and Community Services (LPPM) Diponegoro University, under contract 329-44/UN7.P4.3/PP/2019.

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I am fine... Thank you so much
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