

8th CIRP Conference on Intelligent Computation in Manufacturing Engineering

Stock market related pricing mechanisms for the tool and mould manufacturing industry

B. Denkena^a, A. Nemeti^a *

^aLeibniz Universität Hannover, Institute of Production Engineering and Machine Tools (IFW),
An der Universität 2, 30823 Garbsen

* Corresponding author. Tel.: +49 (0)511 762 18014; fax: +49 (0)511 762 5115; E-mail address: nemeti@ifw.uni-hannover.de

Abstract

Tool and mould manufacturers typically prepare their quotations and tenders in response to customers' requests. The ability to provide an accurate price of, for example, a die casting mould is a key competitive factor for such companies. However, particularly in the customised production area, calculating the quotations and tenders has been proven as extremely challenging and subjective matter. One main cause is that time dynamic costs are rarely taken into consideration sufficiently even though they have a major impact on the final quotation due to the large time frame between the moment of the initial quotation and the actual production start. They neglect can lead to a significant discrepancy of up to 40 percent between pre- and post-calculation and thus to a loss of the corporate added value.

A novel method developed at the Institute of Production Engineering and Machine Tools (IFW), Leibniz Universität Hannover, aims to provide a framework which allows tool and mould manufacturer to prepare a more precise and reliable quotation by taking time-dependent dynamic costs into consideration. The prediction of the time dynamic costs takes place by using stock market pricing mechanisms. Subsequently, based on enterprise related knowledge aggregation, this method also accounts for the probability of occurrence of each quotation thereby minimising the discrepancy between the pre- and post-calculation

© 2013 The Authors. Published by Elsevier B.V. Open access under [CC BY-NC-ND license](https://creativecommons.org/licenses/by-nc-nd/4.0/).
Selection and peer review under responsibility of Professor Roberto Teti

Keywords: Pricing; tool and mould manufacturing industry; time dynamic cost; prediction markets; enterprise related aggregation of knowledge

1. Quotation in tool and mould manufacturing industries

One main factor of economic success of small and medium-sized tool and mould manufacturers in Germany is based on the actual production costs and the pre-determined pricing. Providing their customers with a precise quotation is of particular importance to such companies, since detailed, accurate and transparent pricing is one of the major prerequisites for their competitive and economic activities. Pricing calculations are usually prepared in the early stages of processing a customer's inquiry. However, the actual costs incurred become apparent only after the final realization of the customer's order, furthermore, the order processing procedure may take up more than a year. Figure 1

illustrates the various stages of the contract development from the initial quotation to the production start.

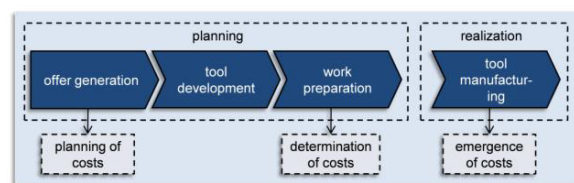


Figure 1: Stages of the contract development in the tool and mould manufacturing industry

Since manufacturers generally offer quotations free of charge, it is necessary to achieve the required pricing accuracy with a minimum of expenditures on their behalf. However, the effort needed to prepare a quotation is often proportional to the quality and

complexity of calculation, which results in a conflict of interest for the manufacturers [1]. In addition to the conventional overhead calculation method, pricing - for approximately 70 percent of the tool and mould manufacturers - are usually based on estimations derived from the past experience of highly-qualified, long-time employees [2].

In the ideal case scenario, the preparation of an adequate and accurate quotation would need the interaction and effort coordination of different company departments such as construction, manufacturing and purchasing. However, in reality, there is usually only a single employee responsible for the calculations who find themselves confronted with a continuously increasing number of customers' inquiries combined with an unchanging, pre-determined calculation period. This results in a greatly reduced time for processing of the individual customers' requests, which in turn can lead to a significant discrepancy - of up to 40 percent [3] - between pre- and post-calculation and thus to a loss of the corporate added value.

2. Optimised and effortless pricing calculation

The Institute of Production Engineering and Machine Tools (IFW), Leibniz Universität Hannover, aims to provide an optimised, effortless method for pricing calculation based on a stock market related pricing mechanism combined with the knowledge of the employees of the company. Apart from providing a transparent and comprehensible pricing for their services, the scheduling of the customers' orders and, thus, the time between the initial estimate and the production start is another essential part of any quotation. Therefore, tool and mould manufacturers should also take the time dynamics of production-related cost factors into consideration. These include time-dependent capacity planning of future machine utilization or the material costs liable to change during the order processing time. The material costs alone, for example, can vary up to 30 percent within a three months period, thus, affecting the production cost significantly [4]. Since current costing concepts are characterised by a large variability in the calculation accuracy and a lack of sufficient consideration of time dynamic costs, a method focussed on the integration of prediction markets in the tool and mould manufacturing industry is presented.

Applying this method and, thereby, accounting for time dynamic cost factors and utilizing prediction markets allows for optimising the pricing in order to minimise pre- and post-calculation costs discrepancies.

2.1. Influence of virtual prediction markets on pricing

Prediction markets are largely electronic stock

exchanges, also known as virtual exchanges, where the pricing is formed between buyers and sellers on the basis of stock shares. Participants in prediction markets can use their personal insights regarding future developments in certain areas, such as political elections, for the purpose of making predictions [5]. The basic idea is to make tradable forecasts regarding future developments by means of virtual shares for both tangible and intangible assets [6, 7]. The efficient market hypothesis, which states that – in the ideal case – market prices already reflect all available information [6, 8] forms the theoretical basis for the operation of prediction markets. Thus, the market price of each virtual share reflects the expectations of the participants in terms of the incoming event.

CHEN and PLOTT's investigations show that, in six out of eight cases, forecasts based on a prediction market where corporate experts have been trading achieve better results than traditional corporate forecasting methods [9]. Furthermore, according to WOLFERS and ZITZEWITZ, the mean absolute error measuring how close predicted events come to actual events is only 2.1 percent in prediction markets [10].

2.2. Use of prediction markets in tool and mould manufacturing industry

Prediction markets provide not only high forecast accuracy but also an ideal platform for combining and consolidating the knowledge of all the employees in the company. Generally, decision-making problems in the dynamic field should be solved objectively, on the basis of timely aggregation of different information sources. This in turn requires a vast coordination effort between various departments involved in the decision-making process, which ultimately proves to be a time-consuming and costly undertaking.

Prediction markets allow for a significant improvement concerning the aggregation and consolidation of the existing information despite its complexity. According to HAYEK, the actions of the market participants influence the price of the traded shares; as a result, this price reflects and objectively evaluates all available information [8]. The exchange of the company employees' knowledge taking place at the prediction market ensures the assessment of the individual decisions and events with regards to their potential impacts within the order processing. The inclusion of time-dynamic costs equals a prediction based on time-dependent factors. By taking into account seasonal over- or under-capacity, manufacturers can plan production and resource utilization economically and efficiently as well as offer attractive and accurate quotations to their customers.

3. Subdivision of the quotation

The first step taken in order to ensure the development and implementation of the theoretical method in a practical application was to determine the requirements which have to be fulfilled in order to guarantee accurate future pricing. These requirements were determined on the basis of the existing procedures applied for pricing in the tool and mould manufacturing industry and they include, inter alia:

- an effortless pricing calculation, due to the high number of quotations which are to be prepared.
- objectivity which does not depend on the person calculating the pricing.
- integration of time dynamic costs in order to account for the period between the pricing and the actual production start.
- high accuracy of the calculation to ensure the reservation of the corporate profitability.

Figure 2 illustrates the desired change from the current quotation calculations associated with a high level of effort to the novel pricing method characterised by a low level of effort.

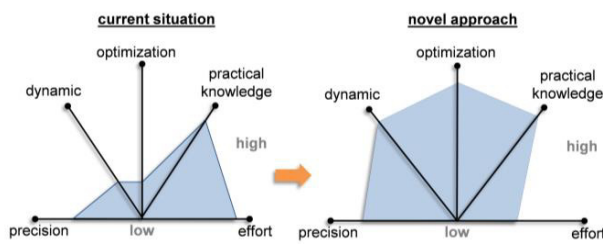


Figure 2: Requirements on future quotation

The price formation of a quotation is influenced by economic and commercial factors which can be connected to three main areas, namely, price discovery, price determination and price argumentation (see Figure 3).

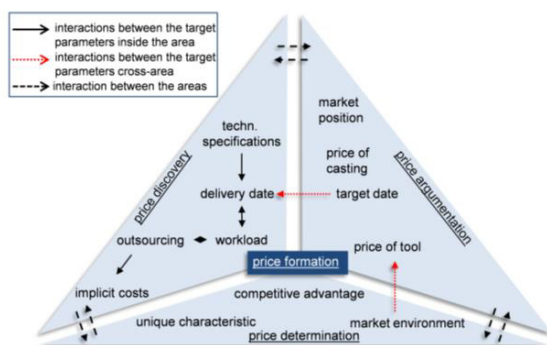


Figure 3: Subdivision of the price formation and description of the target system

According to OXENFELDT [11] the pricing area includes the determination of the internal corporate price based on the specific characteristics of the product. For this purpose, the internal and external value-added processes to be accessed in the future, the expected resource consumption as well as the complexity of form of the products to be manufactured should be evaluated.

The maximum range of the market-related pricing is decided in the price determination field. A comparison between the services provided by the manufacturer and those available on the market can be drawn on the basis of unique characteristics by means of a benchmarking. The price argumentation area is necessary due to the difference between the maximum and minimum pricing range and, correspondingly, the results of the pricing and price determination areas. The price formation is the interface between these three areas. The existence of interactions between these areas is a prerequisite in order to ensure an information transfer needed to optimize the decision making process.

For the above-mentioned elements influencing the price determination, a new target system, based on the demands on the new calculation method, can be developed. Thus, for example, factors such as optimising the technical solution goals, meeting the delivery deadlines, effective resource utilization, reduced outsourcing and ensuring a minimal calculation deviation can be identified as components of the pricing area. The specific objectives of the pricing components are characterised by mutual and interdependent interaction which are shown schematically in Figure 3. As a result, a high demand for an on-time delivery when manufacturing at full capacity influences the goal of reducing the outsourcing.

3.1. Effective model of parameters based on the tool and mould manufacturing

An essential element of the method development includes modeling of the main objective and the parameters as well as their basic data in a mathematically based effect model. The aim here is to identify the relevant time-dependent dynamic costs drivers.

In order to investigate the further goals derived from the requirements as well as to identify the time dynamic costs, the main objectives was divided into their parameters.

KOZIELSKY classifies parameters as numbers, which are relevant for gaining knowledge and which have, therefore, compared to other numbers a special diagnostic value [12]. The aim is to minimise the discrepancies between the pricing calculations and the actual manufacturing costs, which equal target costs and

actual costs. The target costs can be further divided into implicit costs, transportation costs, discounts, etc. The final breakdown of costs leads to the following basic costs set, as shown in Figure 4.

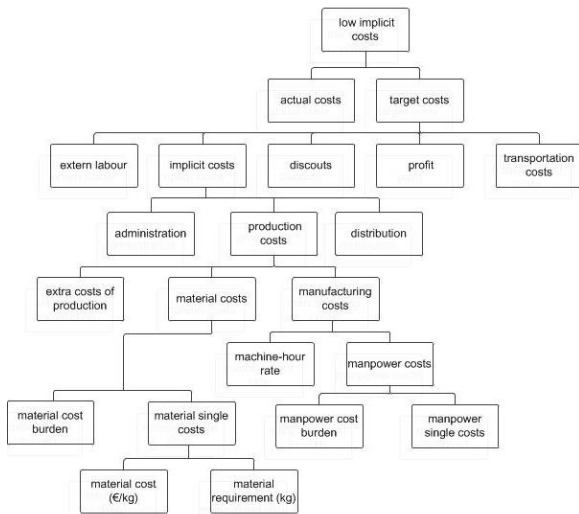


Figure 4: Main target diagram “low implicit costs”

In order to develop the desired method for dynamic pricing in tool and mould manufacturing industry, the created target diagram was transferred into a simulation-based target model based on the simulation model PowerSim. The main criteria for selecting a modeling environment include the formal presentation of the target components and connections. Furthermore, the possibility to describe the functional relationships between the individual target components remains of significant importance.

Figure 5 illustrates a minimal excerpt of the generated mathematical model. As can be seen, the model is based on the target diagram presented in Figure 4. The red rectangle represents the desired objective, i.e. a minimal calculation deviation, as a stock size which undergoes a certain rate of change within a certain time period in accordance with the target differences (parameters in green). The rate of change is represented by the cloud. Furthermore, circles represent auxiliary variables whereas diamonds represent constants. The division of the target objective ends in the basic data. This allows splitting the sum of the material costs into the basic data sets material costs and material requirements.

The time dynamics costs have been identified based on the mathematically represented structure. Using a reference value to signify time-dependent dynamic changes, a marginal validity can be assigned to the respective dynamic costs, therefore, taking into account the time dynamics of the costs.

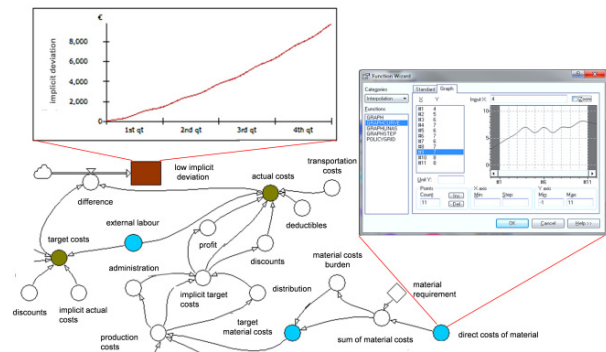


Figure 5: Mathematically represented structure

As dynamic are viewed basic data and parameters whose values have exhibited fluctuations within a period of three months and which, in this context, cannot be regarded as static. The symbols highlighted in blue colours in Figure 5 represent time dynamic cost factors.

By means of performance of a sensitivity analysis six major time-dependent dynamic costs including materials costs, outsourcing, tooling costs, surcharges, machine utilization and human resource allocation has been identified.

Furthermore, it is possible to capture and model the temporal fluctuations of the basic data set, such as the material costs, by means of a software-based tool.

Thus, by mapping their temporal fluctuations in the model, the specific characteristics of the dynamic costs can be taken into account. The formulation of the temporal changes is a result of the applied stochastic functions whose equations can be effectively used to integrate the occurring temporal fluctuations.

Due to their pre-existing interconnections, it is possible, for example, to immediately display how the fluctuations of the material costs impact the calculations and their deviations.

To view the individual targets as an open system, they have been interconnected with each other. Thus, by linking the individual goals, an overarching goal system is implemented.

Having identified the relevant cost drivers, the integration of prediction markets should follow.

4. Characterizations of prediction markets in tool and mould manufacturing industries

The method for integration of prediction markets within the tool and mould manufacturing industry is specified as follows via identifying the time dynamic costs as well as their impact on the corporate goals.

The application of prediction markets in the tool and mould manufacturing industry aims to provide the most accurate quotation possible while still taking into

consideration the time dynamic cost factors which influence it.

The integration of the prediction market takes place during the stage of quotation preparation (Figure 6).

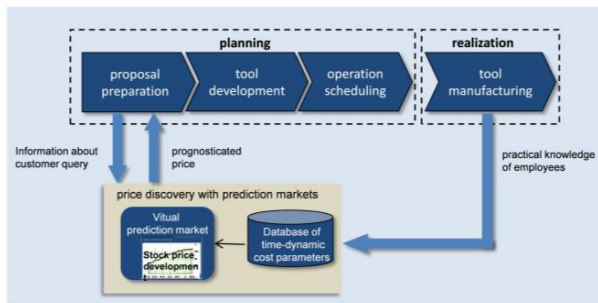


Figure 6: Integration of prediction markets in tool and mould manufacturing industries

The basic idea is that the employees of the company participate in the virtual prediction market based on a fixed target forecast. Participants should be assembled from employees from different departments, for example, controlling, manufacture, etc., so that a significant knowledge aggregation can be guaranteed.

If, for example, the manufacturer receives a customer's order for the production of a form whose delivery is due in six months, the employees can gather at the prediction market to determine the quotation.

Since all of the participants come from diverse information backgrounds with regards to the development course of the time dynamic costs, their usage of the virtual platform, i.e. the stock shares they buy or sell, reflects their individual expectations regarding the quotation to be estimated. Each single share represents, therefore, the time-based price for a given customer order. At the same time, the share price, at which the participants can acquire the shares, represents, according to their intuition, the probability with which that offer price will occur.

Participants can use the platform to monitor the anonymous forecast estimates of the other participants over a given period of time and, if necessary, correct their own forecasts through new shares orders.

To keep the effort manageable, only a small number of participants - six to fifteen people - who can utilise the above-presented method in order to provide their own forecasts within the forecast period flexibly and effortlessly.

To ensure the prediction accuracy, such as when determining the optimal timing for the production start, the integration of the corporate ERP and MRP systems could also be useful.

5. Conclusion

The die and mould manufacturing industry prepare its tenders as a response to its customers' requests. However, the calculation and evaluation of the tenders are often based on the subjective assessment of few corporate employees and can, as a result, exhibit discrepancies of up to 40 percent between calculated pricing and actual production costs. The integration of the pricing of virtual prediction markets including time-dependent dynamic costs provides the tool and mould manufactures with a novel method allowing optimised cost estimation.

By incorporating a virtual prediction market as a part of the enterprise, knowledge aggregation can be ensured which facilitates the determination of the optimal quotation. As a side effect, taking into consideration time-dependent costs dynamic costs factors, such as machine utilization, allows companies to fully and consistently utilize their production processes and resources. The next step includes the implementation of the prediction market in a prototype.

Acknowledgements

The authors would like to thank the German Research Foundation (DFG) for the financial support granted for the research project "Dynamic pricing" (DE 447/73-1).

References

- [1] Denkena, B., Schürmeyer, J., Böß, V., Kaddour, R., 2011. CAD-based cost calculation of mould cavities. In: *Production Engineering Research and Development (WGP)*, 5 (2011) 1, p. 73.
- [2] Denkena, B., Nemeti, A., Schürmeyer, J., Köller, M., 2011. Erarbeitung einer zeitdynamischen Kalkulationsmethode unter Einbeziehung kapazitiver Einflüsse. In: *Zeitschrift für wirtschaftlichen Fabrikbetrieb*, 106 (2011) 3, p. 157.
- [3] Schuh, G., Stich, V., 2011. High resolution supply chain management: optimized processes based on self-optimizing control loops and real time data. In: *Production Engineering Research and Development (WGP)*, 5 (2011) 4, p. 433.
- [4] Rimpau, C., 2010. Knowledge-based risk evaluation during the offer calculation of customised products. In: *Production Engineering Research and Development (WGP)*, 4 (2010) 5, p. 515.
- [5] Wolfers, J., Zitzewitz, E., 2004. Prediction Markets. In: *Journal of Economic Perspectives*, 18 (2004) 2, p. 107.
- [6] Van Bruggen, G.H., Spann, M., Lilien, G.L., Skiera, B., 2010. Prediction markets as institutional forecasting support systems. *Decision Support Systems* 49), p. 404.
- [7] Edward, F.R., 1983. Future markets in transition: The uneasy balance between government and self-regulation. In: *The Journal of Futures Markets*, 3 (1983) 2, p. 191.
- [8] Hayek, F.A., 1945. The use of knowledge in society. In: *American Economic Review*, 35 (1945) 4, p. 519.
- [9] Chen, K.-Y., Plott, C.R. 2002. Information aggregation mechanisms: Concept, design and implementation for a sales

- forecasting problem. In: Social Science Working Paper No. 1131, Institute of Technology, California
- [10] Wolfers, J., Zitzewitz, E., 2004. Prediction Markets. In: Journal of Economic Perspectives, 18 (2004) 2, p. 107.
- [11] Oxenfeldt AR., 1993. The differential method of pricing. In: European Journal of Marketing, 13 (1993) 4, p. 199.
- [12] Kozielski, S.A., 2010. Integratives Kennzahlensystem für den Werkzeugbau. 1st ed. Aachen