LINEAR PROGRAMMING FOR PRODUCTION PLANNING OF FLAT PANEL DISPLAY

By

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(0940510426)

A thesis submitted in fulfillment of the requirements for the degree of the Doctor of Philosophy

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Program Linear Untuk Perancangan Pengeluaran Pelan Panel Flat

ABSTRAK

Perancangan pengeluaran paparan panel rata mempunyai kepentingan kepada Malaysia melalui dua perspektif: akademik dan industri. Pada perspektif akademik, tiada kajian terperinci di peringkat lokal yang dapat memenuhi keperluan industri. Dari perspektif industri pengeluaran paparan panel rata tempatan, industri ini mengalami kesukaran dalam pasaran antarabangsa kerana teknik perancangan pengeluaran yang digunakan adalah terhad, menyebabkan industri tempatan ketinggalan di belakang pesaing. Disertasi ini menumpu kepada pembangunan model yang sesuai untuk digunakan dalam perancangan pengeluaran pembuatan paparan panel rata yang dihasilkan secara tempatan. Tiga (3) model telah dicadangkan untuk digunakan oleh syarikat tempatan, di mana model-model itu mengambilkira keperluan-keperluan teknik pengaturcaraan lurus. Model-model ini merangkumi perancangan pengeluaran secara agregat, fungsi kos seunit yang membawa kepada ramalan di bawah persekitaran kabur, dan perancangan keperluan bahan. Keputusan daripada pelaksanaan model-model tersebut dibandingkan dengan kaedah sedia ada yang digunakan di industri. Keputusan menunjukkan bahawa di bawah keadaan stabil, pelan pengeluaran agregat yang lebih baik boleh diperolehi dengan menggunakan model pengaturcaraan lurus (model 1), manakala di bawah persekitaran kabur, pelan pengeluaran agregat yang lebih baik boleh diperolehi dengan menggunakan model fungsi kos seunit (model 2) yang lebih fleksibel daripada model pengaturcaraan lurus (model 1). Kos pengeluaran, apabila model 1 digunakan, berkurangan sebanyak 34%, manakala kos ini, apabila menggunakan model 2, turun antara 28%-40% berbanding kos kilang sebenar. Model ketiga (model 3), yang menggunakan pengaturcaraan lurus ke atas pelan keperluan bahan, menunjukkan sedikit pengurangan kos berbanding fungsi sistem ERP sedia ada, dan ini menujukkan bahawa ia lebih berkeupayaan untuk membuat ramalan inventori yang kurang berbanding ramalan yang dibuat oleh sistem ERP. Maka, model 3 sangat berkemampuan untuk mencari titik terbaik agar paras inventori yang minimum tercapai, di mana ramalan keadaan yang diperlukan tetap dipenuhi. Di masa akan datang, adalah dijangka bahawa pembangunan dalam bidang ini akan menghasilkan penambahbaikan kepada model-model yang dibangunkan dalam disertasi ini. Untuk memenuhi tujuan, beberapa peluang yang berpotensi yang bersesuaian dikenalpasti untuk ditambahbaik dan ditonjolkan untuk manfaat penyelidik di masa akan datang.

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Linear Programming for Production Planning of Flat Panel Display

ABSTRACT

Production planning of flat panel displays is having a great importance to Malaysia from two perspectives: academic and industrial. From the academic perspective, work that fulfills local industry requirements has not been found. From the perspective of local flat panel display manufacturing industry, the industry is facing greater difficulties in the world market due to the lack of techniques in production planning, causing it to lag behind the competition. This dissertation looks into developing appropriate models to be used in production planning of local flat panel display manufacturers. Three models have been suggested to be used by local companies, whereby the models take into account requirements based on linear programming techniques. The models developed cover aggregate production planning, piecewise cost functions directed towards forecasting under fuzzy environment conditions, and a material requirement plan. Results from the implementation of the models on three industries (A, B, C) are compared with existing methods used in the industries. The results indicated that in stable (deterministic) conditions, an aggregate production plan can be obtained by a linear programming model (model 1), while in a fuzzy environment, a better aggregate production plan can be obtained by piecewise linear production cost functions model (model 2) which is more flexible than the linear programming model (model 1). The cost of production, when model 1 was used, dropped by 34%, while the cost, when using model 2, dropped between 28% - 40% compared to actual factory costs. The total production cost of company A, company B, and company C are presented. Overall, both models linear programming and linear piecewise cost functions minimized the total cost of production for the three companies. Thus, this is an evidence of the applicability of the models. The third model (model 3), which used linear programming on material requirement plan, showed a reduction in cost compared to the in-built ERP system function for company A, company B, and company C, and showed that it is capable of forecasting lower inventory capacity compared to the forecasted results of the current ERP system. Therefore, model (3) is very much capable of finding the best point of attaining minimum inventory levels whilst meeting the forecasted demand conditions. In the future, it is expected that new developments in this field will result in improvements of the models developed in this dissertation. To satisfy this intention, certain key potential opportunities are highlighted to be further improved.

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Flat panel display (FPD) is a rapidly developing industry in the last decades. It is closely interlinked with most of the electronic and electrical products available today. Continuous improvement of the existing characteristics of the FPD, as well as the introduction of FPDs having novel characteristics with different technologies is one of the main reasons for this continuous growth of sales in the international markets. By definition, the product range belonging to FPD include basic routine applications such as television, desktop screen, laptop screen, computer monitor and screen, mobile phone screen, calculator, and camera. There are also specialized niche ends like special medical devices, astronautical products, automobile applications, other multimedia products, and many others. FPDs are far lighter and thinner than the traditional cathode ray tube (CRT) and are usually less than 10 centimeters (3.9 in) thick.

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Wright (2007) stated that FPD production is expected to grow to be up to 98% of the global electronic display product market by the end of 2017. The total market is said to have an estimated overall value of $79 billion at the end of 2006. SRI Consulting (2007) has issued a report on a ten-year forecast of the FPD market, including possible trends, critical success factors, and opportunities. This report also analyses the existing technologies and applications related with the FPD industry.

The technologies related to FPD applications are liquid crystal displays (LCDs), organic light emitting diodes (OLEDs), plasma display panels (PDPs) and field emission and flexible displays (SRI Consulting, 2007). Among these products, liquid crystal display is said to be dominant within the FPD market, with a 77% market capitalization. Its annual expected growth is 17%. It has been estimated that liquid crystal displays have a $ 1 billion market globally, with a total visual area of 39 million square meters at the end of 2007. The total visual area is predicted to be 84 million square meters at the end of 2013.

In Figure 1.1 the existing construction of the flat panel display industry as well as the potential behavior within the next few years are shown. As can be seen from this historical and expected market behavior, liquid crystal displays are the dominant products in global market of flat panel display. Therefore if any research is carried out related with the improving of existing production systems of flat panel displays, main target should be towards the improving the liquid crystal displays further since it carries higher opportunity than to the other mechanisms in terms of returns, compared to others in the display industry.

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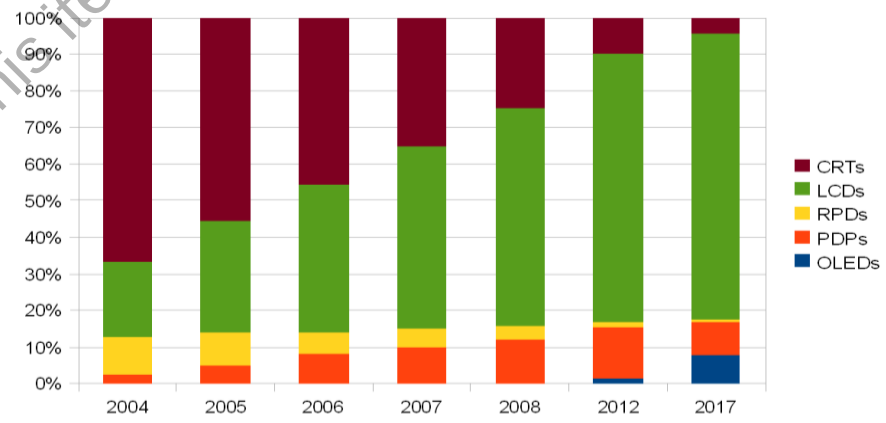

Figure 1.1: Global market construction for the flat panel displays
(Source: SRI Consulting, 2007)

A critical point that must be highlighted is that the FPD is closely interrelated to other industries. This is due to the fact that the FPD, on its own, is not a complete product. It is merely a portion of the end user's requirement. If the contribution of the FPD is vital to the completion of the other products, and if its cost requirement is also the same, then, the relevant products' dependency on the FPD will be immense. Therefore, an in-depth knowledge of the targeted industries' dependency on the FPD should be acquired appropriately. Lalama (1994) identified the cost wise importance of the FPDs in related electronic equipments, as indicated in Figure 1.2.

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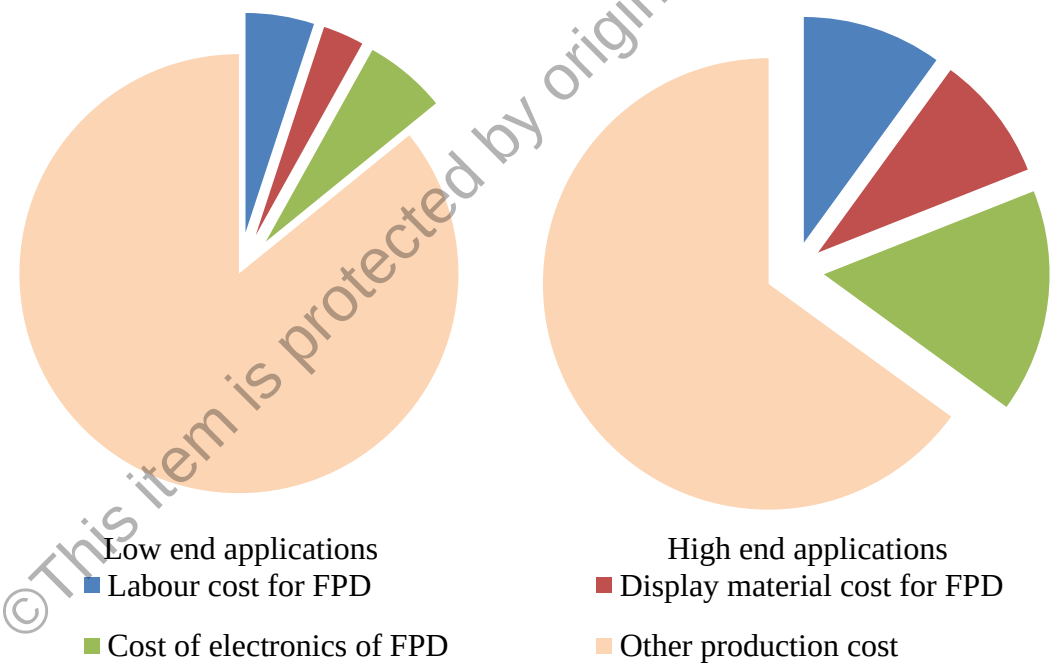

Figure 1.2: Analysis of cost of flat panel display related with total production cost of related appliances. (Source: Lalama, 1994)

All applications related to FPDs are split into two major sections, namely low end and high end applications, as shown in Figure 1.2. Low end applications refer to equipments with small FPDs. An example is that of terminal applications. In contrast, high

end applications refer to applications with large FPDs, like computer screens and some video enhancing applications. The combination of the costs of labor, direct materials, and electronics within the FPDs comprises the total FPD cost representation within a selected application.

Depending on the exact application, for low end applications, the cost of FPDs have been found to be approximately 15% of the cost of the complete product, whilst for the high end applications, the figure is approximately 35%. Therefore it is obvious that whether it is a low end or high end application, the cost of the FPD is quite considerable. Using Porter's (1980) cost leadership strategy, FPD production gives good opportunity for companies to achieve competitive edge over other global companies. Nevertheless it should be noted that to make this happen, proper means of cost controlling should be introduced in relation to FPD manufacturing.

East Asia is considered a leading supplier for FPDs to the worldwide market. According to the NPD group, the global market share is approximately 98%. Four countries, namely Japan, Korea, China and Taiwan have huge market capitalization within this region. Figure 1.3 shows TFT LCD export for portable navigation applications and for automotive monitors. The major FPD manufacturing companies that operate within the region are Samsung, LG display, Chi Mei Innolux, ALIO, Sharp, Sony, Sanyo, Vizio, Toshiba, Citizen, Casio, Hitachi and Panasonic. This implies that it would be difficult for countries like Malaysia to build up FPD capacity and market for export within the region due to the existing intense competition already in place.

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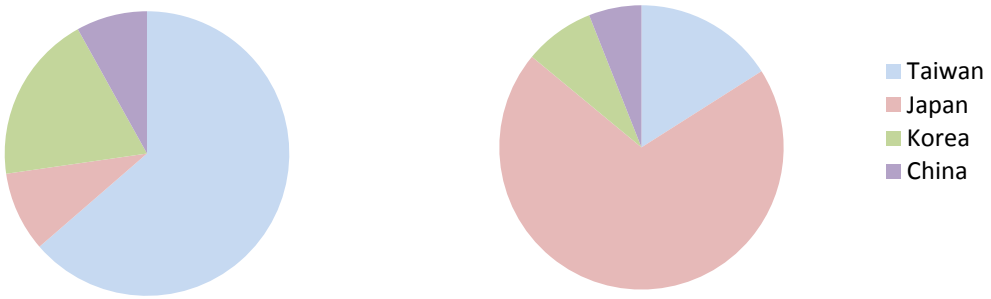

Figure 1.3: TFT LCD manufacturers market share within the East Asia – 2010
(Source: NPD Group, 2010)

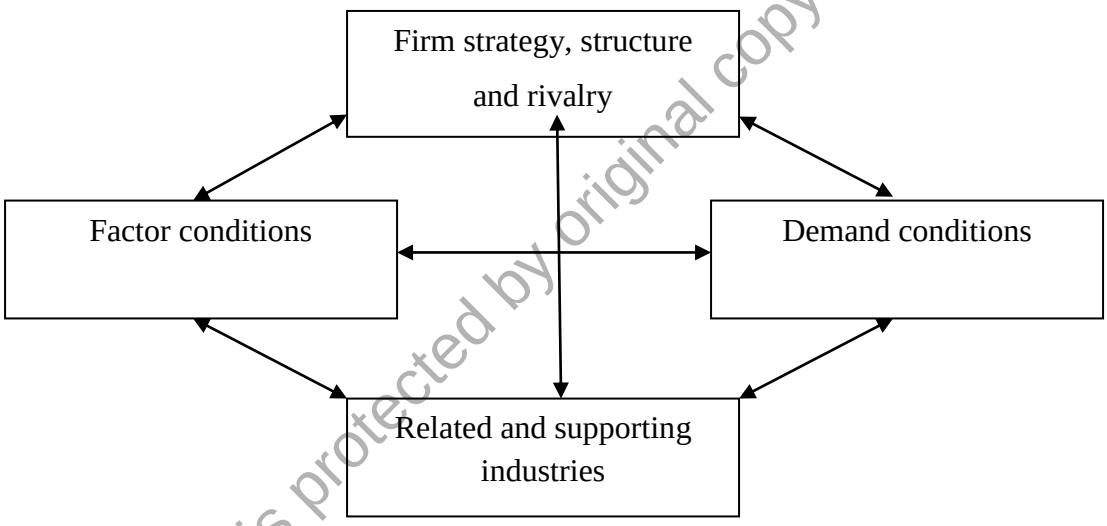

Figure 1.4: Porter's diamond reflecting determinants of competitive advantage
(Source: Porter, 1990)

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Nevertheless, if a new methodology can be developed towards achieving a competitive advantage over others, this might create an opportunity, since demand for FPDs is already established in the region. Using Porter's (1990) Diamond theory, an analysis of the opportunity to attain competitive advantage in FPD manufacturing in Malaysia can be garnered. Through 'firm structure, strategy and rivalry' from the points given in Figure 1.4, a respectable position can be achieved. If Malaysian FPD manufacturers can achieve and sustain itself in the already developed regional market by facing up to the fierce