Enterprise Architecture Analysis with Production Functions

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Enterprise Architecture (EA) is a discipline designed to cope with the complexity of modern enterprises at the intersection of technology and business operations. Enterprises are increasingly dependent on information technology (IT) which is being used for sales, production, human resources management etc. Furthermore, enterprise decision-makers are increasingly concerned with the IT/business interface. There is also a trend towards more data-driven decision-making, and studies show that this pays off in terms of productivity. This presentation ties these two strands – the IT/business interface and data-driven decision-making – together by demonstrating how EA models can be enriched with the production function concept from microeconomics, enabling new and relevant kinds of analysis.

In microeconomics, production functions are used to summarize the production possibilities of a firm; expressing technologically feasible combinations of inputs and outputs. Inputs are typically capital, labor, IT etc. whereas outputs can be any goods or services produced. Mathematically, the production of the maximum amount of output with the minimum amount of inputs can then be formulated as a constrained optimization problem. Optimal solutions are characterized by the condition that the economic rate of substitution (ERS) – the rate at which two inputs can be substituted for each other maintaining a constant cost – equals the technical rate of substitution (TRS) – the rate at which those same inputs can be substituted for each other maintaining constant level of output. This is intuitive: whenever the ERS and the TRS are not equal, either the same output can be produced cheaper, or a larger output can be produced at the same cost, implying that the current state is not optimal.

Now, the useful aspect of this is that there is a large body of literature on production economics, e.g. investigating IT productivity, where production function parameters have been estimated empirically. This means that proposed to-be EA models can be analyzed, using the econometrically estimated parameters, to produce a verdict on whether they are optimal in the sense of production economics.

The approach is demonstrated through three thought experiments:

1. The first example concerns extensive or intensive growth strategies for a company. In this case, we consider a financial analysis firm, operating with two production factors: IT and labor. Thinking about growth strategies, two alternative to-be architectures have been prepared; one for extensive and one for intensive growth. The *extensive* alternative involves hiring more financial analysts, and more first-line IT support. The *intensive* alternative involves firing junior financial analysts, whose work can be automated, replacing them with a Business Intelligence cluster, cutting back on IT support, and hiring some more qualified IT staff to manage the cluster. How should the chief information officer (CIO) evaluate these alternatives? The two growth strategies are basically about re-adjusting the balance between the IT and labor production factors. Thus, the two architectures can be evaluated by combining econometrically estimated parameters from the literature with the actual case data from the architectures (i.e. quantities of staff and IT equipment) to find the ERS and the TRS. The closer the TRS/ERS ratio is to unity, the closer the proposed architecture is being optimal.

2. The second example concerns strategies for high availability IT services. Consider a business critical IT service with high requirements on availability. The service might be part of an industrial or business process where downtime entails large costs, or it might be part of some critical infrastructure where downtime poses significant risks to human life. Assuming that we need to meet a certain availability level (e.g. 99.81 %), should a manager aim for a longer mean time to failure (MTTF) or a shorter mean time to recovery (MTTR)? Assuming that capital can buy better hardware (or more of the same, to build redundancy), thus increasing the MTTF, and that labor can be used to monitor the system and take swift action if it fails, thus decreasing the MTTR, this problem can formulated and solved as a constrained production economics optimization problem. Given capital and labor costs, this allows for solving the trade-off between MTTR and MTTF, i.e. reaching a given availability level in the cheapest way, or, alternatively, spending a fixed budget to achieve the highest possible availability.
3. The third example concerns optimal composition of a military unit. A military unit can consist either of a few pieces of high quality equipment manned by a few soldiers, or of many pieces of low quality equipment manned by many soldiers. How can the trade-off between quality and quantity be made? Based on the Lanchester differential equations describing attrition warfare, this problem can be formulated as a constrained production economics optimization problem. Given a reference enemy (red) force (i.e. quantities of soldiers, tanks, infantry fighting vehicles and artillery pieces), and assumptions about relative qualities of blue (our) and red equipment, the relative fighting strengths of blue force architectures (i.e quantities of soldiers and equipment) can be evaluated. If, additionally, assumptions are made about the prices of buying more quality and quantity, optimal compositions can be found.

The common factor in all three examples is that information already present in EA models (e.g. the number of employees, the IT systems used in operations, or the number of tanks in a military unit) can be further exploited using the production function concept from microeconomics. This allows a number of business analysis concerns to be addressed, following the literature on production economics. The approach is demonstrated with three examples.

Apart from the third example above, which is novel, the proposed presentation is based on the following previous publication:

- Ulrik Franke. Enterprise Architecture Analysis with Production Functions. In *IEEE 18th International Enterprise Distributed Object Computing Conference (EDOC 2014)*, pages 52–60. IEEE, 2014. doi:10.1109/EDOC.2014.17.