# ASSESS THE FINANCIAL PERFORMANCE OF TECHNOLOGY TRANSFER ENTITIES USING EXISTING ECONOMIC AND FINANCIAL MODELS

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*Abstract: This paper evaluates the financial performance of technology transfer entities (TTEs) by analyzing both economic and financial models. Traditional financial models, such as Discounted Cash Flow (DCF) and Capital Asset Pricing Model (CAPM), provide insights into investment viability and risk management in TTEs. Economic models, like IS-LM and growth models, help understand the macroeconomic environment's influence on technological innovation. Specific models, such as the linear innovation model and the Triple Helix framework, emphasize the collaboration between academia, industry, and government in fostering innovation. The integration of real options analysis and venture capital methods further supports investment decisions in high-uncertainty technological projects. This approach helps TTEs optimize resource allocation and strategic investments, contributing to sustainable economic growth.*
*Keywords: financing, innovation, technology transfer entities (TTE) financial models*

## Introduction

Traditional financial models are less frequently used in their classical form in the field of technology transfer, as this process involves not only financial aspects but also complexities related to innovation, intellectual property, collaboration between different entities and adaptation to market conditions. For this reason, both economic and financial models need to be analysed. Economic modelling focuses on the understanding and forecasting of economic phenomena, taking into account many macroeconomic and microeconomic factors. In contrast, the financial model focuses on analysing the financial performance of specific companies or projects, assessing the efficiency of investments. Although the two models interact and influence each other (e.g. economic conditions can affect the financial performance of companies), they serve different purposes and use distinct approaches and tools. Economic models provide a broad perspective on the economic context and impact of technology transfer, while financial models are geared towards the specific valuation and management of technology transfer assets and projects. Economic models are essential for understanding the general economic environment and the macroeconomic impact of innovation, while financial models are critical in the decision-making process regarding financial investments in technology transfer activities. The main difference between an economic and a financial model lies in the purpose, scope and variables used.

## Economic models

Economic models are used for macroeconomic and microeconomic analysis, focussing on understanding broad (national or sectoral) economic dynamics and the complex interactions between markets and economic agents. These models explain and predict

economic behaviours, the impact of economic and fiscal policies, the dynamics of economic growth and how various market forces converge towards financial equilibrium. For technology transfer entities (TTEs), these models provide a framework for understanding the economic context of technology transfer, the influence of economic policies on innovation and research and development (R&D) investment, and the macroeconomic impact of technology transfer (Klein L. R, 2000); (Li H. and Wu X., 2015); (Navarro C. E. B. and Tomé R. M. B., 2022) Economic models are based on variables such as gross domestic product (GDP), inflation rate, unemployment, interest rates, demand and supply of goods and services, fiscal and monetary policies. Economic growth models are designed to explain the mechanisms and factors that contribute to long-term economic growth. Robert Solow's neoclassical economic growth model, developed in 1956, is a landmark in modern economic theory, providing a fundamental explanation of the dynamics of long-term economic growth. The model is based on three main factors influencing economic growth: capital accumulation, population growth and technological progress. Solow points out that although capital accumulation and labour force expansion contribute to economic growth, they have a limited long-run effect, leading to diminishing returns (Solow, R. M., 1956). Therefore, in the absence of technological progress, economies will tend to reach a point of equilibrium where growth stagnates.
A central element of the model is the 'Solow residual', which is the part of economic growth that cannot be explained by capital and labour accumulation. This residual is attributed to technological progress and efficiency gains, which are key factors in sustaining long-term economic growth. Technological progress is regarded as an exogenous variable, i.e. independent of economic decisions, suggesting that government policies should focus on creating an environment favourable to innovation and efficiency to stimulate growth. Solow's model has important implications for fiscal policies, highlighting the need for investment in physical and human capital, as well as R&D, to support economic growth. The model also suggests that, in the long run, the finances of technology transfer entities tend to converge to a stable rate of growth, influenced by technological advancement. Therefore, ETTs with higher saving rates will experience accelerated growth initially; however, in the long run, growth differentials between these technology transfer entities will narrow as they reach a point of equilibrium. On the other hand, the endogenous growth model emphasises innovation and education, technology transfer, which stimulates the accumulation of knowledge and human capital (Hunt S. D., 2012); (Dykas P. et al., 2022).

**The IS-LM (Investment and Saving - Liquidity Preference and Money Supply)**
Model The IS-LM model analyses the interaction between the goods and money markets. The IS-LM model helps to assess the impact of fiscal and monetary policies on FTEs and has its origins in Keynesian economic theory. Munir in his research on South Asia emphasises that money supply has a positive but insignificant effect on the gross savings of FTEs. In contrast, per capita GDP growth significantly influences saving behaviour. This result reinforces the idea that saving is not just a function of interest rates but is affected by broader economic conditions. Thus, in addition to interest rates, income and other macroeconomic factors such as monetary and fiscal policy have a significant impact on saving behaviour (Munir, K., 2023). Moreover, the relationship between savings and investment is further clarified by the work of Alguacil who provides empirical evidence supporting the idea that savings precede and cause innovation growth (Alguacil, M., et al.,

2004). This causal relationship supports the Keynesian assertion that higher savings can lead to higher levels of investment in innovation and, consequently, higher economic growth. Thus, domestic economies can play a crucial role in the investment process, contributing to the long-term development of national economies. This also aligns with the neoclassical growth model, which emphasises the importance of economies in determining investment, with Sothan confirming this relationship by emphasising the role that domestic economies play in stimulating economic growth (Sothan, S., 2014).

In addition, recent studies have also explored liquidity preference and its role in the investment behaviour of ETTs. In the context of economies with costly external financing, the relationship between savings and investment in innovations becomes more complex and dependent on contextual conditions, as supported by the model proposed by Tsoukalas. They suggest that the sensitivity of cash flows varies across investment regimes, which complicates investment analysis. In such contexts, ETTs' liquidity preference and behaviours become crucial factors in determining how much these firms save and invest (Tsoukalas et al., 2016). This view is also supported by research by Riddick and Whited, who explore how cash flows influence ETTs' propensity to save and ultimately their investment decisions in innovation. They argue that firms with higher cash holdings are more likely to save and invest because they have easier access to internal financing, thus avoiding the constraints imposed by the high costs of external financing (Riddick, L. A. and Whited, T. M., 2009).

Macroeconomic policies also play a key role in influencing the saving and investment behaviour of FTEs. Research by Farmer and Lahiri (2006) emphasises the importance of economic interdependence between countries and how this influences saving and investment patterns. They suggest that fiscal measures need to take these interdependencies into account in order to effectively stimulate economic growth. In globalised economies, macroeconomic policies cannot be conceived in isolation, as their effects extend beyond national borders, influencing the economies of trading partners and, reciprocally, domestic economies (Farmer, R. E. A., and Lahiri, A., 2006). Schmidt adds an international dimension to this discussion, suggesting that global economic conditions can have a significant impact on domestic saving behaviour and investment opportunities of FTEs. As economies become increasingly interconnected, global economic trends, such as changes in international interest rates, fluctuations in exchange rates and changes in trade policy, can influence the saving and investment decisions of domestic firms and governments (Schmidt, R., 2001). This emphasises the need to consider not only domestic but also international economic factors when analysing saving and investment dynamics.

General Equilibrium Models General equilibrium models are complex and attempt to explain market behaviour and resource allocation in innovation, taking into account the interactions between different markets. The best known example is the Arrow-Debreu model, which demonstrates the conditions under which a general equilibrium exists in the economy, ensuring an efficient allocation of resources (Arrow K. J. et al., 1983); (Townsend R. and Prescott E., 1984).

**Financial models**

Financial models are used to evaluate technology transfer assets, innovations, start-ups or spin-offs, with a focus on investment analysis, cost of capital and financial structure. The purpose of financial models is to estimate the present value of assets or projects, to analyse the return and risk of investments and to optimise financial decisions. An example of such a model is the Capital Asset Pricing Model (CAPM - Capital Asset Pricing Model), which determines the expected rate of return of an asset in relation to its systemic risk (Montani D. et al., 2020).

*Discounted cash flow (DCF) models*
DCF models are valuation techniques used by Technology Transfer Entities to estimate the present value of future cash flows generated by an asset or innovation. They are essential in evaluating technology transfer projects as they help to determine their financial viability and intrinsic value (Montani, D., et al., (2020).

*Term structure models of interest rates*
Term structure models of interest rates, such as the Vasicek model or the Cox-Ingersoll-Ross (CIR) model, are used to describe the behaviour of long-term interest rates and to estimate the yield curve of innovations. These models play an important role in the valuation of fixed-income financial instruments and have major implications for the financing of technology transfer, especially in terms of the cost of financing and the selection of debt instruments. Understanding the structure of interest rates helps to model financing costs and (Montani, D., et al., 2020), to assess the risk associated with different financing strategies for technology transfer projects.

*Real Options Analysis (ROA)*
Real Options Analysis (ROA) is an advanced valuation method that provides flexibility in investment decisions in technology transfer projects. By treating technology investments as a series of options that can be exercised depending on market and technology developments, ROA is particularly useful in situations of high uncertainty, allowing the entities involved to make step-by-step decisions and capitalise on options such as project extension, postponement or abandonment (Montani, D., et al., 2020).

*Venture Capital Method (VCM)*
The Venture Capital Method (VCM), also known as the First Chicago Method, is used to evaluate start-ups and early-stage innovative companies, which is commonly associated with technology transfer. This method involves estimating the future value of the company based on growth expectations and applying a discount factor to calculate the present value, taking into account the amortisation rate expected by investors (Montani, D., et al., 2020).
In conclusion, we can conclude that each of the financial models and methods of analysis discussed provide valuable tools for evaluating and managing technology transfer investments. These models contribute to decisions about resource allocation and investment strategies. Although many of these models can be considered as strictly financial orientated, their application in the finance of Technology Transfer Entities requires a deep understanding of the technology specificities, the target market, the technology life cycle and the associated risks. In practice, financial models are often integrated with technical and market analyses to ensure well-informed assessments and decisions.

**Technology transfer specific models**

In practice, technology transfer organisations (TTOs) also use other technology transfer specific models, which combine elements of all the above approaches. Financial models specific to TETs focus on the mechanisms and strategies by which knowledge and innovations are transferred from research to industry for commercialisation and deployment. Among the best known models in this context are: the linear innovation model, the Triple Helix model and the open innovation model.

*The linear model of innovation*

The linear model of innovation is one of the oldest and most simplified financial models describing the process of innovation and technology transfer. This model conceptualises the innovation process as an orderly sequence of phases, starting from basic research and ending with commercialisation. Although this model does not directly address financial analysis or market mechanisms, it has important economic implications, emphasising the role of basic research as a source of innovation. However, the model has been criticised for oversimplifying the innovation process and neglecting market feedback.

*The Triple Helix Model*

The Triple Helix Model, developed by Henry Etzkowitz and Loet Leydesdorff, proposes an innovative paradigm in the study of the dynamics of innovation and the finance of Technology Transfer Entities. This model goes beyond the traditional view of the separate roles of universities, industry and government, suggesting that synergy and collaboration between these three sectors can accelerate technological and economic progress. Universities are no longer just centres for research and education, but become active economic actors, contributing to start-ups and regional economic development. Industry also stimulates applied research and supports academic development through partnerships, and government facilitates collaboration through financial resources and an appropriate regulatory framework (Etzkowitz, 1998). The Triple Helix model promotes the creation of new hybrid structures, such as science parks and business incubators, which facilitate knowledge and technology transfer, helping to commercialise innovations and stimulate economic growth in a knowledge-based economy-oriented framework. Universities play a central role, not only through research activities, but also through their active involvement in entrepreneurship and innovation (Kunwar and Ulak, 2023); (Cai and Amaral, 2021). As we will show below the triple helix model has evolved by including various new components. For example, Prasetio introduces the concept of "ambidextrous organisationalism" to define an organisation that can balance profitability with innovation and development (Prasetio, T., et al., 2022).

*The Open Innovation Model*

The Open Innovation Model, conceptualised by Henry Chesbrough, has fundamentally changed the way innovation is managed in companies. It proposes an interactive framework where external knowledge and competences are systematically integrated into companies' innovation processes. The model emphasises that bidirectional flows of information and technology can enrich innovation capability and shorten time-to-market for innovative products (Chesbrough H., 2003). Technology transfer entities play a key role in this model, acting as nodes that facilitate interaction between companies, universities and other research organisations. The open innovation model recognises the importance of cross-sectoral collaboration and knowledge sharing, supporting a dynamic and adaptive innovation ecosystem. Implementing this model requires a collaborative organisational culture and openness to external sources of innovation Chesbrough H., 2003).

**The University Technology Transfer Model**

The University Technology Transfer Model provides a framework through which knowledge and innovations generated in academic institutions are transferred to industry and commerce for practical application. This model was fostered by the Bayh-Dole legislation, which allowed universities to own the intellectual property rights to federally funded inventions, stimulating collaboration between universities and industry. Dedicated structures, such as Technology Transfer Offices (TTOs), play a key role in identifying marketable innovations, protecting intellectual property and facilitating industrial partnerships, says Mowery. This model highlights the importance of synergistic relationships between universities, industry and government, recognising the need for an appropriate legislative and financial environment to maximise the impact of technology transfer (Mowery, D., 2015).

*The Technology Transfer Through Intermediaries Model*

The Technology Transfer Through Intermediaries Model emphasises the role of specialised entities, such as Technology Transfer Offices (TTOs), in facilitating the exchange of knowledge and technology between academia and industry. These entities assess the commercial potential of innovations, protect intellectual property and negotiate licensing agreements. Through OTTs, universities and companies collaborate effectively to transform scientific discoveries into innovative products and services (Feldman, 2002). This model recognises the significant added value of intermediaries in the innovation process, which optimise technology transfer through collaborative networks between universities, companies and other entities (Feldman, 2002).

*The Academic Innovation Ecosystem Model*

The Academic Innovation Ecosystem Model describes a complex and interconnected environment around universities, in which different actors work together to stimulate the innovation process. In addition to universities and Technology Transfer Offices, industrial partners, investors, incubators and government policies play key roles in this ecosystem. This model emphasises the importance of intense collaboration between academia, industry and other stakeholders to accelerate the innovation process (Angrisani et al., 2022; Angrisani et al., 2023). Angrisani's research explores the importance of the academic innovation ecosystem, emphasising the critical role of universities in promoting knowledge and technology transfer and facilitating entrepreneurship. The ecosystem includes interactions between innovation, entrepreneurship and technology transfer ecosystems (Angrisani et al., 2022).

**Quadruple and quintuple helix models**

The Triple Helix model has subsequently evolved into the quadruple helix model and, more recently, the quintuple helix model, which adds new dimensions to emphasise the involvement of other actors in financial innovation ecosystems. In this extended framework, in addition to academia, industry and government, other entities such as civil society, business, NGOs and other research institutions are included. These extended models aim to enhance collaboration and innovation within entrepreneurial ecosystems, expanding the sphere of influence and contributing to financial and social development through technology transfer (Cloitre et al., 2022). An important step in the development of these models has been the integration of the circular economy into the fivefold helix. Borrero and Yousafzai emphasise the potential of the circular economy, from the integration of product and service systems to eco-industrial innovations, with universities being seen as central actors in this transition (Borrero and Yousafzai, 2024).

*Unified Theory of Helicidal Architectures (EUTOHA)*
Carayannis and Campbell extended the helical models by proposing an emerging Unified Theory of Helicidal Architectures (EUTOHA). Within this theory, the Quintuple Innovation Helix (QIH) model represents an advanced theoretical construct that integrates five dimensions essential for the sustainable and democratic development of modern knowledge-based economies: environment, civil society, government, academia and industry. This holistic approach is essential for addressing the complex challenges in knowledge-based economies (Carayannis and Campbell, 2022).

*The Sextuple Helix Model*
Gouvea and Li have adapted the quintuple helix model to analyse the relationships between people with disabilities and jobs in smart economies. The authors emphasise that countries with advanced information and communication technology (ICT) infrastructure have lower unemployment rates among people with disabilities. These societies also have robust education systems, effective health services and an open and dynamic business environment. In contrast, countries with high disability unemployment rates tend to perform more poorly on these six dimensions (Gouvea and Li, 2021). The Sextuple Helix framework provides an integrated approach to analysing disability unemployment, including ICT, education, health, economics and infrastructure, providing a comprehensive perspective on economic disparities (Gouvea and Li, 2021).

*Integrating circular economy into helix models.*
Successive helix models Integrating the circular economy into helix innovation models offers a significant opportunity for transforming economies. Universities, as centres of innovation, can become key contributors to the transition to a circular economy, aligning with their economic and societal responsibilities. This integration encourages the development of innovative eco-industrial practices and sustainable solutions in areas such as resource management and waste minimisation (Borrero and Yousafzai, 2024).

## Conclusions

Existing economic and financial models provide a sound theoretical and practical framework for assessing the financial performance of technology transfer entities. Economic models, such as IS-LM and economic growth models, allow an understanding of the macroeconomic context and the impact of technology transfer at national or sectoral level. At the same time, financial models, such as the CAPM and DCF, are essential for assessing the financial value of innovative assets and projects in the field of technology transfer. Technology transfer specific models, such as the linear innovation model, the Triple Helix model and open innovation models, are essential for understanding and optimising the technology transfer process. These models recognise the iterative and collaborative nature of innovation and emphasise the importance of integrating academic, industrial and government actors in financial innovation ecosystems.

Recent developments, such as the quintuple helix model and the mainstreaming of the circular economy, reflect the need for greater collaboration between different sectors to address contemporary economic and technological challenges. Universities play a central role in this process, not only as knowledge producers but also as facilitators of innovation and technology transfer. By adopting these models and approaches, technology transfer entities can maximise the impact of innovation and contribute to sustainable economic growth.

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