Substrate Token Economics:
Annotated Bibliography Scoping Review*

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Abstract

This project provides a annotated bibliography "Scoping Review" to highlight some tools and techniques relevant to the design of a token economy.

Contents

1 Background

This project emerged from an effort to take a token-economy design and bootstrap some settings for a launch state. That is also the scope of the ideas and topics raised here - a bootstrapping exercise. The context is a competitive equilibrium setting rather than any non-competitive Nash-only type of equilibrium. The definition of "Rational Expectations" is due to John Muth:[1]

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1. John F. Muth, "Rational Expectations and the Theory of Price Movements," *Econometrica* 29 (1961): 315.

Table 1: Native Token-Economy Types: Polkadot Ecosystem

Chain	Token	Economy	Model	Equilibrium	Sector	Production	Monetary
Equilibrium	EQ	Open[a]	Structural	Partial[b]	52[c]	None	None

[a] This economy is Open in terms of borrowing and lending tokens.

[b] The state price process isn't explicitly specified (some references suggest a Black-Scholes-Merton type, others a jump-diffusion), hence it is not possible to identify a single supporting partial equilibrium with confidence. Nonetheless, I describe the effort as a partial equilibrium.

[c] Financial Services in the North American Industry Classification System.

> In order to explain fairly simply how expectations are formed, we advance the hypothesis that they are essentially the same as the predictions of the relevant economic theory.

Calculating a competitive equilibrium in these settings is generally done via fixed point theorems. For examples: Robert Lucas[2] defines a rational expectations equilibrium as a fixed point in a space of functions of Markov state vectors, while Thomas Sargent[3] defines it as a fixed point in a space of stochastic processes. Since then, a multitude of introductory text book treatments have emerged. Darrell Duffie's text[4] is considered a sound introduction, with an orientation exercise in Chapter 1 illustrating the use of a fixed point theorem to establish whether an equilibrium exists.

2 Token-Economy Taxonomy

This analysis of the Parachain tokenomics is limited to publicly available whitepapers or token-economy/tokenomics documentation. Initial proposal flow-chart/decision-tree development that will help developers place their token in the following contexts. Types under the following topics

Model: structural vs reduced form

Economy: open vs ajar vs closed

Equilibrium: partial vs general

Sectors: public vs private, financial vs real and their interactions

Production: Cobb-Douglas vs constant elasticity of substitution

Monetary: Quantity Theory of Money vs Fiscal Theory of the Price Level etc.

Other attributes/specifications of a native token economy that are generally absent are: Agent Utility, Market Rates (Riskless Rates + Risk Premia), Rate Curves (by maturity), Borrowing/Lending, Lender of Last Resort.

The Equilibrium Parachain is a notable exception:

2. Robert Jr. Lucas, "Expectations and the neutrality of money," *Journal of Economic Theory* 4, no. 2 (April 1972): 103–124.

3. Thomas J Sargent, "A Note on the 'Accelerationist' Controversy," *Journal of Money, Credit and Banking* 3, no. 3 (August 1971): 721–725.

4. D. Duffie, *Dynamic Asset Pricing Theory: Third Edition*, Princeton Series in Finance (Princeton University Press, 2001).

It is fair to say that most Parachain have not found it necessary to specify their token-economy by including or analyzing the effects of the above considerations. It is difficult to sustain the argument that this has adversely affected the ability to raise capital. For those funded via Initial Coin Offerings, one can argue this access to capital absent even cursory evidence the 'economy' is sustainable, simply reflects the exploitative nature of ICOs. However, that argument is less plausible where capital has been raised more scrupulously (i.e. compliance with the minimal investor safeguards regulators require) and with more difficulty, from sophisticated Venture Capital funds.

A plausible conjecture is that all participants regard any deterioration of their economy as improbable or:

1. slow to emerge,

2. have self evident causes and

3. those causes will be reversible.

2.1   Economy Type
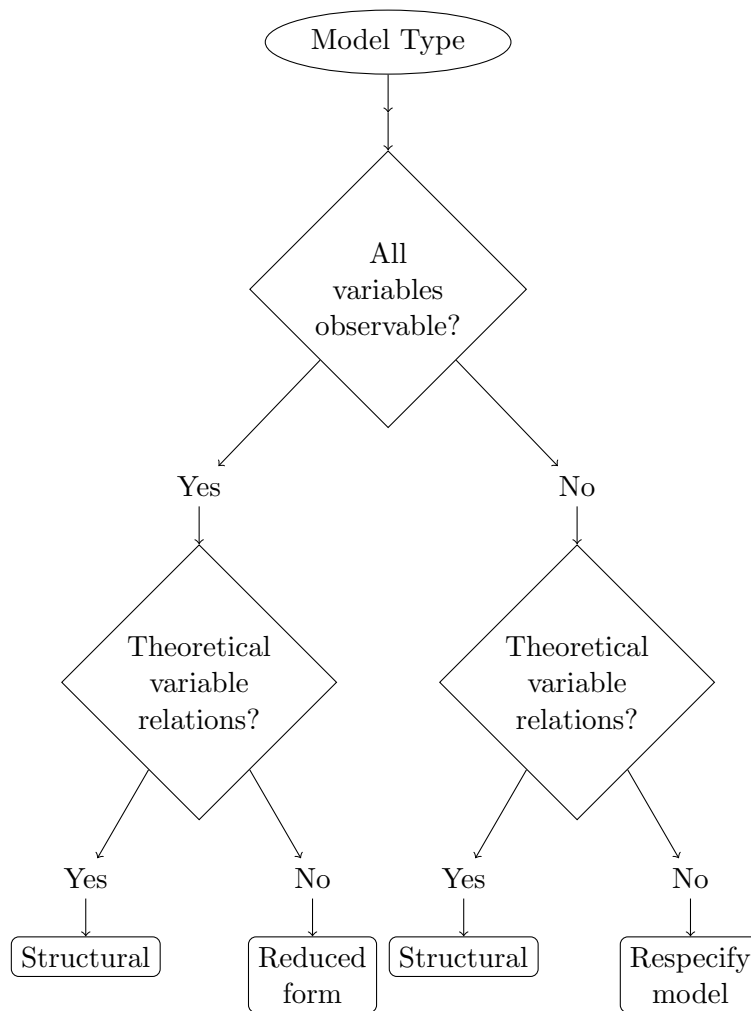
A token-economy is open if it engages in unrestricted staking and rewarding with the native coins (NC) of other token-economies, and if it accepts the NC of other token-economies as medium of payment for its transaction fees. Otherwise the token-economy is ajar or closed. Similar classification can be done using tokens in place of NC. Here staking refers to efforts to secure the blockchain.
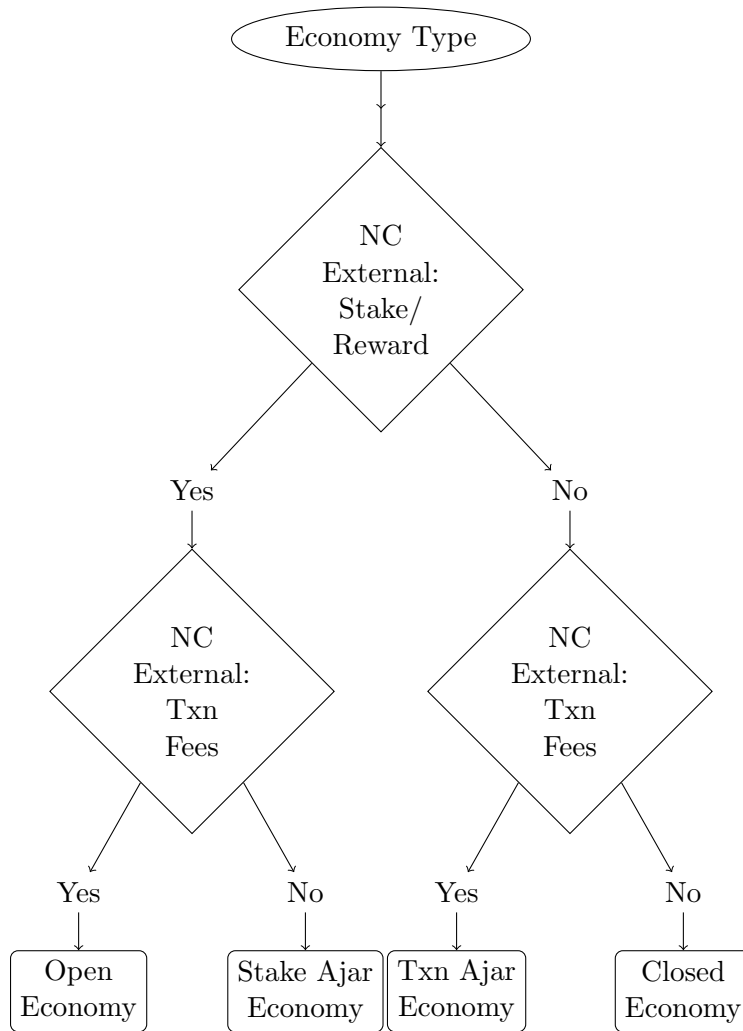
2.2 Model Type

Reduced-form models express relations between endogenous variables in terms of observable exogenous variables. Structural models derive from a theory, describe behavior at a deeper level and may include un-observable parameters. Often the choice of approach is driven by data and estimation/calibration considerations. Absent data, simulations are often used.

Model Type

All variables observable?

Yes — No

Theoretical variable relations?

Theoretical variable relations?

Yes — No

Yes — No

Structural

Reduced form

Structural

Respecify model

general equilibrium theory attempts to explain the behavior of supply, demand, and prices in a whole economy with several or many interacting markets, by seeking to prove that the interaction of demand and supply will result in an overall general equilibrium. General equilibrium theory contrasts to the theory of partial equilibrium, which analyzes a specific part of an economy while its other factors are held constant.

2.3 Equilibrium Type

In a general equilibrium model, the over-all equilibrium quantities and prices are calculated endogenously, usually starting with initial endowments and a model of agent behavior - the objective is to describe changes in prices and quantities such that the result is "Pareto Optimal". A partial equilibrium model analyzes a specific part of an economy (assuming others parts constant or even absent), frequently either the price or quantity process is specified and the other derived from it, hence necessitates a reduced-form model. Often a partial equilibrium approach results in "no-trade" outcomes. When possible, it can be useful to calculate a structural equivalent equilibrium that "supports" a reduced-form partial equilibrium specification, and vice versa.
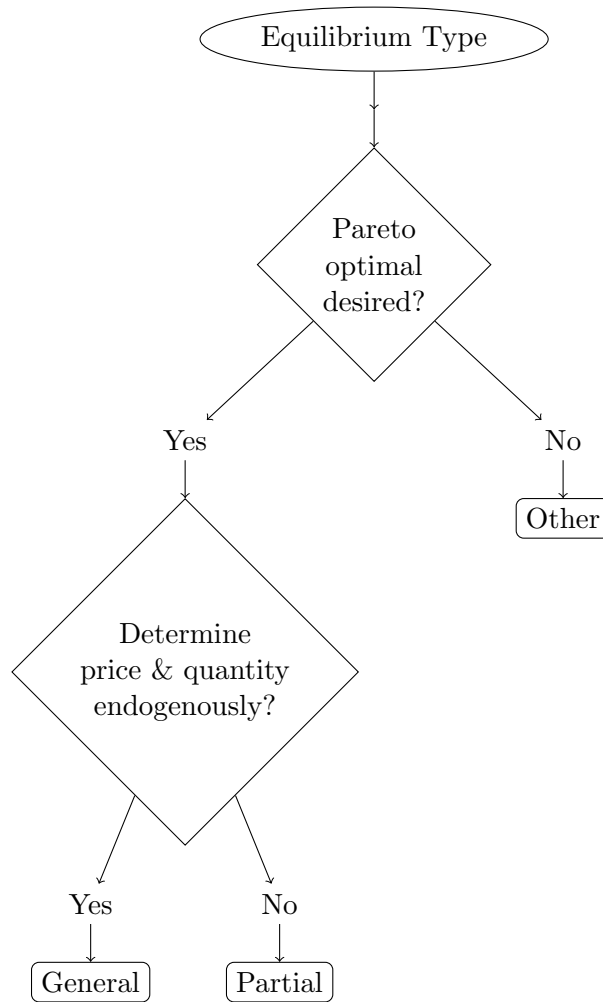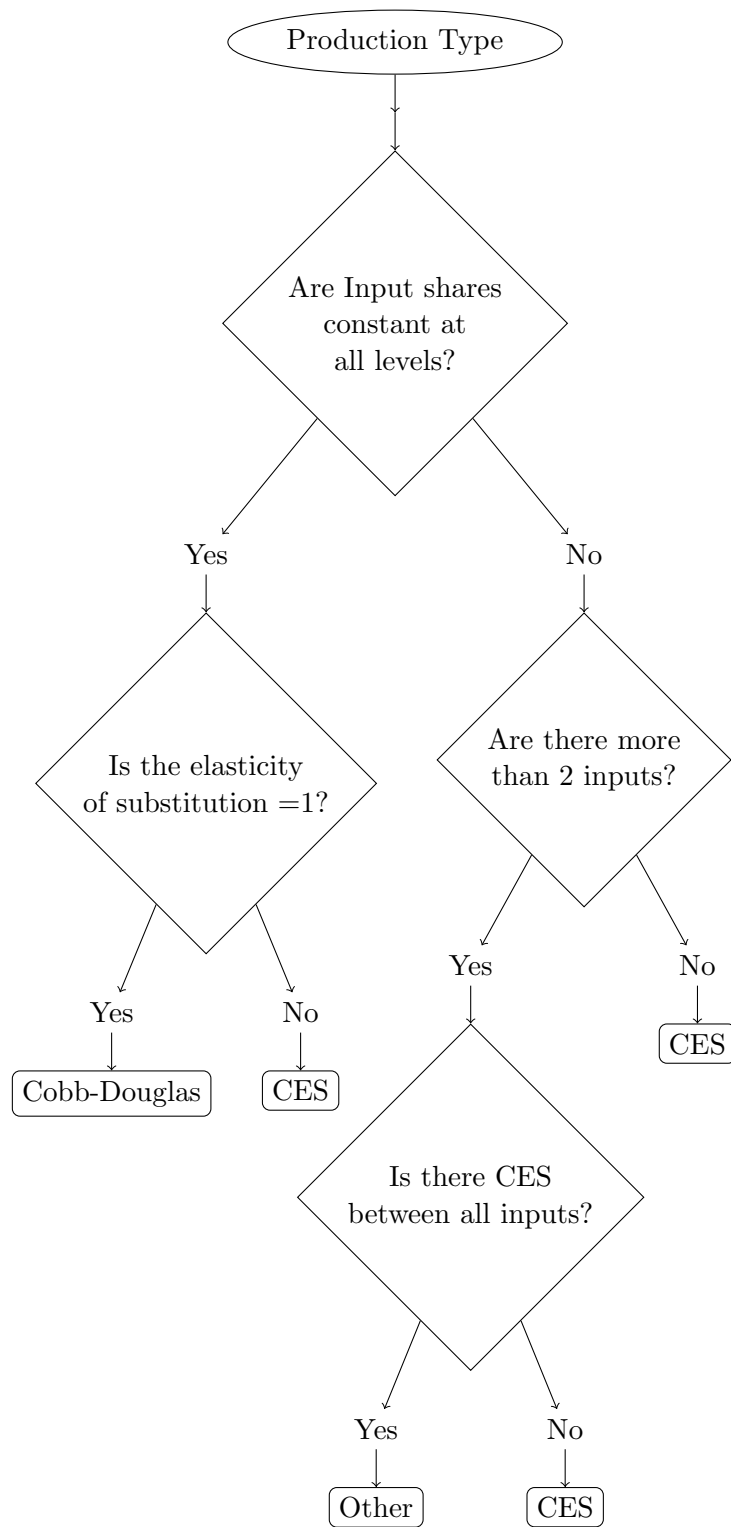
2.4 Sector Type

Multisector models are used to explore the allocation of resources across different activities, e.g. validator staking vs non-validator bonding. Commonly studied are consumption vs investment, public vs private, real vs financial sectors. It is becoming more common to model more than two sectors, the number and character of each sector is either self evident, or too unique to be summarized in a decision tree.

2.5 Production Type

A production function is a specification of how the quantity of output behaves as a function of the inputs used in production. In both general and partial equilibrium settings it is used to connect different parts of an economy, for example the Production-CAPM[5]. Only two production functions are considered here: The Cobb-Douglas (C-D) and the Constant Elasticity of Substitution[6] (CES). Elasticity of substitution (ES) is a measure of how easy it is to shift between factor inputs - the percentage change in the ratio of the two inputs relative to the percentage change in their prices.

5. John H. Cochrane, "Production-Based Asset Pricing and the Link Between Stock Returns and Economic Fluctuations," *The Journal of Finance* 46, no. 1 (1991): 209–237, https://doi.org/https://doi.org/10.1111/j.1540-6261.1991.tb03750.x, eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1540-6261.1991.tb03750.x

6. Leontief, linear and Cobb–Douglas functions are special cases of the CES production function.

2.6 Monetary Type

Monetary Policy is one of the most fraught topics in macroeconomics. There is no consensus on an unconditionally optimal policy. Rather the designer of a token-economy will be left to chose from among the alternatives below.

Table 2: Monetary Policy Types

Monetary Target	Target Variable	Objective
Inflation	Interest rate	A given rate of change in an index
Price Level	Interest rate	A specific index number
Monetary Aggregate	Growth in money supply	A given rate of change in an index
Exchange Rate	The spot price of the currency	The spot price of the currency
Collateral peg	Collateral spot price	Low inflation as measured by the collateral price

2.7 Native Token Functions

In light of the above the functional classification of

Table 3: Native Token Functions: Polkadot Ecosystem

Chain	Token	Fuel	Transaction	Voucher
Polkadot	DOT Y	Y	N	N
Acala	ACA	Y	N	N
Astar	ASTR	Y	N	N
Bifrost	BFC	Y	Y	N
Centrifuge	CFG	Y	N	N
Clover	CLV	Y	Y	N
Composable	LAYR	Y	N	N
Crust	CRU	Y	Y	Y
Darwinia	RING	Y	N	N
Efinity	EFI	Y	N	N
Equilibrium	EQ	Y	Y	N
HydraDX	HDX	Y	N	N
Interlay	INTR	Y	N	N
KILT	KILT	Y	N	N
Moonbeam	GLMR	Y	N	N
Nodle	NODL	Y	N	N
OriginTrail	TRAC/OTP	Y	Y	N
Parallel	PARA	Y	N	N
Phala	PHA	Y	N	Y
Statemint	DOT	Y	N	N
Unique	UNQ	Y	N	N

3 Notation

4 Annotated Bibliography

Cong, Lin William, and Zhiguo He. "Blockchain Disruption and Smart Contracts." *The Review of Financial Studies* 32, no. 5 (2019): pp. 1754–1797.

TBC. The demand shock X_t follows a geometric Brownian motion with drift μ_x and volatility σ_x so that

$$dX\_t = \mu\_x X\_t dt + \sigma\_x X\_t dz\_t, \tag{1}$$

where z_t is a standard Wiener process, and X_0 is strictly positive. We further assume that X_0 is sufficiently low so that the growth options of all firms in the industry are strictly positive at $t = 0$. Throughout the paper, we denote by $\mu\_\mathbf{y}t$ and $\sigma\_\mathbf{y}t$ the mean and standard deviation of any variable y at time t, and we omit the subscript t when $\mu\_\mathbf{y}$ or $\sigma\_\mathbf{y}$ are constant over time.

Cong, Lin William, Ye Li, and Neng Wang. "Token-based platform finance." *Journal of Financial Economics* 144, no. 3 (2022): 972–991. https://doi.org/10.1016/j.jfineco.2021.10.

TBC.

———. "Tokenomics: Dynamic Adoption and Valuation." *The Review of Financial Studies* 34, no. 3 (August 2020): 1105–1155. https://doi.org/10.1093/rfs/hhaa089. eprint: https://academic.oup.com/rfs/article-pdf/34/3/1105/36264622/hhaa089.pdf.

TBC.

Rogoff, Kenneth, and Yang You. "Redeemable Platform Currencies." *The Review of Economic Studies* 90, no. 2 (May 2022): 975–1008. https://doi.org/10.1093/restud/rdac028. eprint: https://academic.oup.com/restud/article-pdf/90/2/975/49435191/rdac028.pdf.

TBC.

A Scope

The prevalence of crypto-currencies means the decision to exclude them warrants some explanation. Microeconomic (partial) equilibria are generally explicitly constructed (which proves existence) using conjectured properties of the dividends (or an equivalent) from the economic activity. Specifically, a price is the present-value (i.e. discounted for time and non-diversifiable risk), of all future dividends. Since the dividends of fiat currencies are zero this approach does not work. While there are workarounds, they, being particular, are not of interest in the more general settings I wish to bring to light.

B Methodology

The published research annotated are the top-10 articles selected from the commercial research databases available from the State Library of New South Wales. This list was arrived at in the following stages:

1. Preparation: by operationalizing the inquiry *"Refereed articles on block-chain token-economics using rational expectations equilibrium (a.k.a. no-arbitrage) arguments/analysis, ranked by journal impact factors"*;

2. Retrieval: eliminating duplicates;

3. Screening: removing false positives; ranking by journal impact factor;

4. Selection: selecting the top-10; and

5. Write-up: reviewing remaining article abstracts and substituting where judged appropriate.

Operationalized on ProQuest:

Source types: Scholarly Journals Journal type: Peer reviewed Query: (rational expectations NEAR/2 equilibrium) OR (no PRE/2 arbitrage OR arbitrage PRE/2 free) AND ((block NEAR/2 chain) AND ((token NEAR/2 economics) OR (tokenomics)))

Notes: '(rational expectations) NEAR/2 equilibrium': Captures general and partial equillibrium '(no PRE/2 arbitrage) OR (arbitrage PRE/2 free)': Captures

https://eresources.sl.nsw.gov.au/proquest-central-proquest ("token economics" OR tokenomics) - language: English - 90 results - screened: - Bubbly Bitcoin - Bitcoin as a Safe-Haven Asset and a Medium of Exchange - Crypto-currency bubbles: An application of the Phillipsâ€"Shiâ€"Yu (2013) methodology on Mt. Gox bitcoin prices - The economics of Bitcoin and similar private digital currencies - Trading and arbitrage in cryptocurrency markets - Portfolio diversification with virtual currency: Evidence from bitcoin - Is Bitcoin really untethered? - Does Bitcoin add value to global industry portfolios? - Inflation and Bitcoin: A descriptive time-series analysis - Optimal Cryptocurrency and BIST 30 Portfolios with the Perspective of Markowitz Portfolio Theory - On the inefficiency of Bitcoin - The inefficiency of Bitcoin revisited: A dynamic approach - Cryptocurrency Forecasting: More Evidence of the Meese-Rogoff Puzzle - Theories of Crowdfunding and Token Issues: A Review - What can blockchain do and cannot do? - Understanding token-based ecosystems â€" a taxonomy of blockchain-based business models of start-ups - selected:

https://eresources.sl.nsw.gov.au/academic-onefile-gale

https://eresources.sl.nsw.gov.au/abiinform-proquest - .. results - screened: .. - Blockchain, Bitcoin, and ICOs: a review and research agenda - What can blockchain do and cannot do? - Internet of Things: Business Economics and Applications - The token's secret: the two-faced financial incentive of the token economy - Cong, Lin William; Li, Ye; Wang, Neng. Token-based platform finance. Journal of Financial Economics ; 2021; 144 , pp. 972-91. [DOI: https://dx.doi.org/10.1016/j.jfineco.2021.10.002] - Cong, Lin William; Li, Ye; Wang, Neng. Tokenomics: Dynamic adoption and valuation. The Review of Financial Studies ; 2021; 34 , pp. 1105-55. [DOI: https://dx.doi.org/10.1093/rfs/hhaa089]

https://eresources.sl.nsw.gov.au/jstor-search-journals-primary-sources-and-books-jstor ("token economics" OR tokenomics) - language: English - journals: Business, Economics, Finance - 16 results - screened: 2 - selected: 1, Lin William Cong and Zhiguo He, "Blockchain Disruption and Smart Contracts," *The Review of Financial Studies* 32, no. 5 (2019): pp. 1754–1797

The annotated bibliography component of this project is closest to a "Scoping Review", see[7]

Each section of the report/working paper was developed using some subset of the following iterative process (see[8])

1. Review reporting guidelines, best practice handbooks, and training modules [preparation stage]

2. Formulate question and decide on review type [preparation stage]

3. Search for previous published literature [preparation stage]

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7. Maria J. Grant and Andrew Booth, "A typology of reviews: an analysis of 14 review types and associated methodologies," *Health Information & Libraries Journal* 26, no. 2 (2009): 91–108, https://doi.org/https://doi.org/10.1111/j.1471-1842.2009.00848.x, eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1471-1842.2009.00848.x.

8. Guy Tsafnat et al., "Systematic review automation technologies," *Systematic Reviews* 3, no. 1 (July 2014): 74, https://doi.org/10.1186/2046-4053-3-74.

Table 4: Scoping Review: Extract from Table 1 of Grant, M.J. and Booth, A. (2009)

Description	Search	Appraisal	Synthesis	Analysis
Preliminary assessment of potential size and scope of available research literature. Aims to identify nature and extent of research evidence (usually including ongoing research)	Completeness of searching determined by time/scope constraints. May include research in progress	No formal quality assessment	Typically tabular with some narrative commentary	Characterizes quantity and quality of literature, perhaps by study design and other key features. Attempts to specify a viable review

4. Develop and test search strategies [preparation stage]

5. Review search strategies [preparation stage]

6. Execute search [retrieval stage]

7. De-duplicate data/information [retrieval stage]

8. Screen title and abstracts [screening stage]

9. Retrieve full-text articles [retrieval stage]

10. Screen articles in full-text [screening stage]

11. Search for grey literature (preprints, working papers) [retrieval stage]

12. Quality assessment and data/information extraction [synthesis stage]

13. Citation chasing [retrieval stage]

14. Update database searches [retrieval stage]

15. Synthesize data/information [synthesis stage]

16. Manuscript development [write-up stage]