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Poverty Traps and Disaster Insurance in a Bi-level Decision Framework

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Chapter

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Abstract

In this paper, we study mechanisms of poverty traps that can occur after large disaster shocks. Our starting point is a stylized deterministic dynamic model with locally increasing returns to scale possibly generating multiple equilibria paths with finite upper equilibrium. The deterministic dynamics is then overlayed by random dynamics where catastrophic events happen at random points of time. The number of events follows a Poisson process, whereas the proportional capital losses (given a catastrophic event) are beta distributed. In a setup with fixed insurance premium per unit of insured capital, a fraction of the capital might be insured, and this fraction may change after each event. We seek for an optimal strategy with respect to the insured fraction. Falling below the instable equilibrium of the deterministic dynamics introduces the possibility of ending up in a poverty trap after the disaster shocks. We show that the trapping probability (over an infinite time horizon) is equal to one when the stable upper equilibrium of the deterministic dynamics is finite. This is true regardless of the chosen amount of insured capital. Optimization then is done with the expected discounted capital after the next catastrophic event as the objective. Our model may also be useful to assess risk premia and creditworthiness of borrowers when a sequence of shocks at uncertain times and of uncertain size occurs.

JEL Classification:

C 61 C 63 L 10 L 11 L 13

Notes

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Appendix: Numerical Solution Procedure (NMPC)

For the numerical solution of the deterministic model presented in Sect. 3.2, and used further in the next sections, we do not apply here the dynamic programming (DP) approach as presented in Grüne and Semmler [11] and as used in the original paper of Semmler and Ofori [32]. Though DP method also can find the global solution to an optimal growth model with multiple equilibria by using a fine grid for the control as well state variables but its numerical effort typically grows exponentially with the dimension of the state variable. Thus, even for moderate state dimensions it may be impossible to compute a solution with reasonable accuracy.

Instead computing the solution at each grid point as DP do we here use a procedure that is easier to implement. We are using what is called nonlinear model predictive control (NMPC) as proposed in Gruene and Pannek [38] and Gruene et al. [12]. Instead of computing the optimal solution and value function for all possible initial states, NMPC only computes single (approximate) optimal trajectories at a time. To describe the NMPC procedure we can write the optimal decision problem as

$$\text{maximize} \quad \int_0^\infty e^{-\rho t} \ell(x(t), u(t)) dt,$$

(3.16)

where $x(t)$ satisfies

$$\dot{x}(t) = g(x(t), u(t)), \quad x(0) = x_0.$$

(3.17)

By discretizing this problem in time, we obtain an approximate discrete-time problem of the form

$$\text{maximize} \quad \sum_{i=0}^\infty \beta^i \ell(x_i, u_i),$$

(3.18)

where the maximization is now performed over a sequence u_i of control values and the sequence x_i that satisfies $x_{i+1} = \Phi(h, x_i, u_i)$. Hereby $h > 0$ is the discretization time step. For details and references where the error of this discretization is analyzed we refer to Grüne et al. [12].

The procedure of NMPC consists in replacing the maximization of the infinite horizon functional (3) by the iterative maximization of finite horizon functionals

$$\text{maximize} \quad \sum_{k=0}^N \beta^i \ell(x_{k,i}, u_{k,i}),$$

(3.19)

for a truncated finite horizon $N \in \mathbb{N}$ with $x_{k+1,i} = \Phi(h, x_{k,i}, u_{k,i})$. Hereby the index *i* indicates the number of iterations. Note that neither β nor ℓ nor Φ changes when passing from (3.18) to (3.19). The procedure works by moving ahead with a receding horizon.

The decision problem (3.19) is solved numerically by converting it into a static nonlinear program and solving it by efficient NLP solvers, see Gruene and Pannek [38]. In our simulations, we have used a modification of NMPC, as developed by Gruene and Pannek [38], in their routine `nmpc.m`, available from `www.nmpc-book.com`, which uses MATLAB's `fmincon` NLP solver in order to solve the static optimization problem. Our modification employs a discounted variant of the NMPC MATLAB version, see [12].

Given an initial value x_0, an approximate solution of the system (3.16)–(3.17) can be obtained by iteratively solving (3.19) such that for i = 1, 2, 3, that solves for the initial value initial value $x_{0,i} := x_i$ the resulting optimal control sequence by $u^*_{k,i}$, but uses only the first control $u_i := u^*_{0,i}$ and iterates forward the dynamics $x_{i+1} := \Phi(h, x_i, u_i)$ by employing only the first control. Thus, the algorithm yields a trajectory x_i, $i = 1, 2, 3, \ldots$ whose control sequence u_i consists of all the first elements $u^*_{0,i}$ of the optimal control sequences of the finite horizon problem (3.19). Under appropriate assumptions on the problem, it can be shown that the solution (x_i, u_i), which depends on the choice of *N* in (3.19), converges to the optimal solution of (3.16) as $N \to \infty$, see [12].

Figure 3.8 illustrates the working of the algorithm. The upper black line represents the solution at the step i = 1 with the decision horizon N = 4. This is iterated forward 6 times, thus we have i = 1 ... 6. The lower red line is the outer envelop of the piecewise solutions using the horizon N = 4 multiple times, in our case 6 times. The figure A1 shows the solution for 6 iterations.

While the algorithm can be used to solve for optimal trajectories of *x* and *u*, it can also be applied for estimating time derivatives $\dot{x}(t)$: This is achieved by plugging the optimal decision u_0 into the differential equation (3.17). Using this estimate, avoids tedious recalculation of trajectories throughout the present paper.

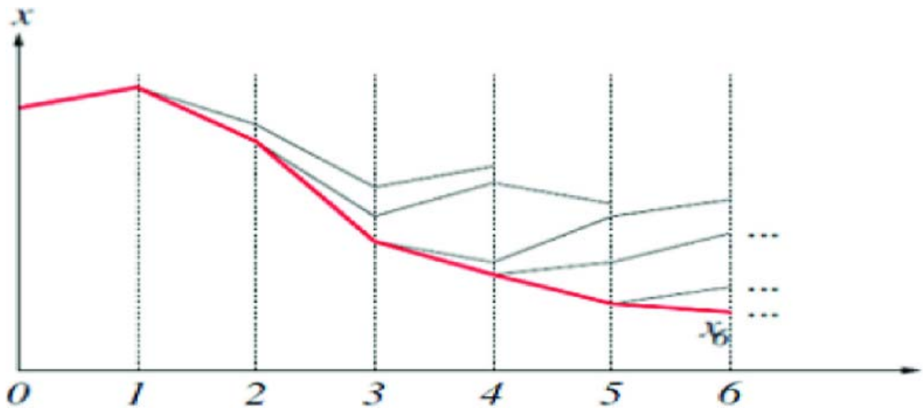

Fig. 3.8

Receding horizon solution

The main requirement in these assumptions is the existence of an optimal equilibrium for the infinite horizon problem (3.19)–(3.17). If this equilibrium is known, it can be used as an additional constraint in (3.19), in order to improve the convergence properties. In our solution of the model in Sect. 3.2, and further on, we did not use the terminal condition to solve the model but moved forward with a receding horizon to find the (approximate optimal) trajectories. Thus, without a priory knowledge of this equilibrium this convergence can also be ensured. Though the proofs in earlier work were undertaken for an undiscounted NMPC procedure, however, the main proofs carry over to the discounted case, details of which can be found in Gruene et al. [12].

References

1. Arrow, K. (1962). The economic implications of learning by doing. *Review of Economic Studies*, *29*, 155–173.
   CrossRef (https://doi.org/10.2307/2295952)
   Google Scholar (http://scholar.google.com/scholar_lookup?title=The%20economic%20implications%20of%20learning%20by%20doing&author=K.%20Arrow&journal=Review%20of%20Economic%20Studies&volume=29&pages=155-173&publication_year=1962)
2. Azariadis, C. (2001). The theory of poverty traps: What have we learned? Mimeo, UCLA.
   Google Scholar (https://scholar.google.com/scholar?q=Azariadis%2C%20C.%20%282001%29.%20The%20theory%20of%20poverty%20traps%3A%20What%20have%20we%20learned%3F%20Mimeo%2C%20UCLA.)
3. Azariadis, C., & Drazen, A. (1990). Threshold externalities in economic development. *Quarterly Journal of Economics*, *105*(2), 501–526.
   Google Scholar (https://scholar.google.com/scholar?q=Azariadis%2C%20C.%2C%20%26%20Drazen%2C%20A.%20%281990%29.%20Threshold%20externalities%20in%20economic%20development.%20Quarterly%20Journal%20of%20Economics%2C%20105%282%29%2C%20501%E2%80%93526.)
4. Azariadis, C., & Stachurski, J. (2004). Poverty traps. In P. Aghion & S. Durlauf (Eds.), *Handbook of economic growth*. Elsevier Publisher.
   Google Scholar (https://scholar.google.com/scholar?q=Azariadis%2C%20C.%2C%20%26%20Stachurski%2C%20J.%20%282004%29.%20Poverty%20traps.%20In%20P.%20Aghion%20%26%20S.%20Durlauf%20%28Eds.%29%2C%20Handbook%20of%20economic%20growth.%20Elsevier%20Publisher.)
5. Barro, R. J., & Ursua, J. F. (2008). *Macroeconomic crises since 1870*. Working Paper 13940, National Bureau of Economic Research.
   Google Scholar (https://scholar.google.com/scholar?q=Barro%2C%20R.%20J.%2C%20%26%20Ursua%2C%20J.%20F.%20%282008%29.%20Macroeconomic%20crises%20since%201870.%20Working%20Paper%2013940%2C%20National%20Bureau%20of%20Economic%20Research.)
6. Barro, R. J. (2006). Rare disasters and asset markets in the twentieth century. *The Quarterly Journal of Economics*, *121*(3), 823–866.

CrossRef (https://doi.org/10.1162/qjec.121.3.823)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Rare%20disasters%20and%20asset%20markets%20in%20the%20twentieth%20century&author=RJ.%20Barro&journal=The%20Quarterly%20Journal%20of%20Economics&volume=121&issue=3&pages=823-866&publication_year=2006)

7. Burke, M., Hsiang, S. M., & Miguel, E. (2011). Global non-linear effect of temperature on economic production. *Nature,527*, 235–239.
Google Scholar (https://scholar.google.com/scholar?q=Burke%2C%20M.%2C%20Hsiang%2C%20S.%20M.%2C%20%26%20Miguel%2C%20E.%20%282011%29.%20Global%20non-linear%20effect%20of%20temperature%20on%20economic%20production.%20Nature%2C527%2C%20235%E2%80%93239.)
8. Burke, E. J., Perry, R. H. J., & Brown, S. J. (2010). An extreme value analysis of UK drought and projections of change in the future. *Journal of Hydrology*, *388*(2010), 131–143.
CrossRef (https://doi.org/10.1016/j.jhydrol.2010.04.035)
Google Scholar (http://scholar.google.com/scholar_lookup?title=An%20extreme%20value%20analysis%20of%20UK%20drought%20and%20projections%20of%20change%20in%20the%20future&author=EJ.%20Burke&author=RHJ.%20Perry&author=SJ.%20Brown&journal=Journal%20of%20Hydrology&volume=388&issue=2010&pages=131-143&publication_year=2010)
9. Dechert, W. D., & Nishimura K. (1983). Complete characterization of optimal growth paths in an aggregated model with a non-concave production function. *Journal of Economic Theory, 31*(2), 332–354.
Google Scholar (https://scholar.google.com/scholar?q=Dechert%2C%20W.%20D.%2C%20%26%20Nishimura%20K.%20%281983%29.%20Complete%20characterization%20of%20optimal%20growth%20paths%20in%20an%20aggregated%20model%20with%20a%20non-concave%20production%20function.%20Journal%20of%20Economic%20Theory%2C%2031%282%29%2C%20332%E2%80%93354.)
10. Gabaix, X. (2011). Disasterization: A simple way to fix the asset pricing properties of macroeconomic models. *The American Economic Review*, *101*(3), 406–409.
CrossRef (https://doi.org/10.1257/aer.101.3.406)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Disasterization%3A%20A%20simple%20way%20to%20fix%20the%20asset%20pricing%20properties%20of%20macroeconomic%20models&author=X.%20Gabaix&journal=The%20American%20Economic%20Review&volume=101&issue=3&pages=406-409&publication_year=2011)
11. Greiner, A., Semmler, W., & Gong, G. (2005). *The forces of economic growth: A time series perspective*. Princeton: Princeton University Press.
CrossRef (https://doi.org/10.1515/9781400880157)
Google Scholar (http://scholar.google.com/scholar_lookup?title=The%20forces%20of%20economic%20growt

h%3A%20A%20time%20series%20perspective&author=A.%20Greiner&author=W.%20Semmler&author=G.%20Gong&publication_year=2005)

12. Gruene, L., & J. Pannek. (2011). Nonlinear model predictive control, Theory and algorithms. Springer Verlag, London.
Google Scholar (https://scholar.google.com/scholar?q=Gruene%2C%20L.%2C%20%26%20J.%20Pannek.%20%282011%29.%20Nonlinear%20model%20predictive%20control%2C%20Theory%20and%20algorithms.%20Springer%20Verlag%2C%20London.)

13. Gruene, L., Semmler, W., & Stieler, M. (2015). Using nonlinear model predictive control for solving dynamic decisions problems in economics. *Journal of Economic Dynamic and Control*, *60*, 112–133.
CrossRef (https://doi.org/10.1016/j.jedc.2015.08.010)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Using%20nonlinear%20model%20predictive%20control%20for%20solving%20dynamic%20decisions%20problems%20in%20economics&author=L.%20Gruene&author=W.%20Semmler&author=M.%20Stieler&journal=Journal%20of%20Economic%20Dynamic%20and%20Control&volume=60&pages=112-133&publication_year=2015)

14. Grüne, L., & Semmler, W. (2004). Using dynamic programming with adaptive grid scheme for optimal control problems in economics. *Journal of Economic Dynamics and Control*, *28*, 2427–2456.
CrossRef (https://doi.org/10.1016/j.jedc.2003.11.002)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Using%20dynamic%20programming%20with%20adaptive%20grid%20scheme%20for%20optimal%20control%20problems%20in%20economics&author=L.%20Gr%C3%BCne&author=W.%20Semmler&journal=Journal%20of%20Economic%20Dynamics%20and%20Control&volume=28&pages=2427-2456&publication_year=2004)

15. Gumbel, E. (1935). Les valeurs extremes des distributions statistiques. *Annales de l'institut Henri Poincare*,*5*(2), 115–158.
Google Scholar (https://scholar.google.com/scholar?q=Gumbel%2C%20E.%20%281935%29.%20Les%20valeurs%20extremes%20des%20distributions%20statistiques.%20Annales%20de%20l%E2%80%99institut%20Henri%20Poincare%2C5%282%29%2C%20115%E2%80%93158.)

16. Gumbel, E. (1958). *Statistics of extremes*. Columbia University Press.
Google Scholar (https://scholar.google.com/scholar?q=Gumbel%2C%20E.%20%281958%29.%20Statistics%20of%20extremes.%20Columbia%20University%20Press.)

17. Hochrainer, S., Mechler, R., & Pflug, G. (2009). *Assessing current and future impacts of climate-related extreme events—The case of Bangladesh*. Interim Report IR-09-030, International Institute for Applied Systems Analysis.
Google Scholar (https://scholar.google.com/scholar?q=Hochrainer

%2C%20S.%2C%20Mechler%2C%20R.%2C%20%26%20Pflug%2C%20G.%20%282009%29.%20Assessing%20current%20and%20future%20impacts%20of%20climate-related%20extreme%20events%E2%80%94The%20case%20of%20Bangladesh.%20Interim%20Report%20IR-09-030%2C%20International%20Institute%20for%20Applied%20Systems%20Analysis.)

18. Hochrainer-Stigler, S., Mechler, R., Pflug, G., & Williges, K. (2014). Funding public adaptation to climate-related disasters. Estimates for a global fund. *Global Environmental Change*, *25*, 87–96. CrossRef (https://doi.org/10.1016/j.gloenvcha.2014.01.011) Google Scholar (http://scholar.google.com/scholar_lookup?title=Funding%20public%20adaptation%20to%20climate-related%20disasters.%20Estimates%20for%20a%20global%20fund&author=S.%20Hochrainer-Stigler&author=R.%20Mechler&author=G.%20Pflug&author=K.%20Williges&journal=Global%20Environmental%20Change&volume=25&pages=87-96&publication_year=2014)

19. Independent Evaluation of the Asian Development Bank. (2015). *Global increase in climate-related disasters*. Google Scholar (https://scholar.google.com/scholar?q=Independent%20Evaluation%20of%20the%20Asian%20Development%20Bank.%20%282015%29.%20Global%20increase%20in%20climate-related%20disasters.)

20. Kovacevic, R. M., & Pflug, G. C. (2011). Does insurance help to escape the poverty trap?—A ruin theoretic approach. *Journal of Risk and Insurance, 78*(4), 1003–1028. CrossRef (https://doi.org/10.1111/j.1539-6975.2010.01396.x) Google Scholar (http://scholar.google.com/scholar_lookup?title=Does%20insurance%20help%20to%20escape%20the%20poverty%20trap%3F%E2%80%94A%20ruin%20theoretic%20approach&author=RM.%20Kovacevic&author=GC.%20Pflug&journal=Journal%20of%20Risk%20and%20Insurance&volume=78&issue=4&pages=1003-1028&publication_year=2011)

21. Kremer, M., Onatski, A., & Stock, J. (2001). *Searching for prosperity*. NBER Working Paper Series, Working Paper 8020. Google Scholar (https://scholar.google.com/scholar?q=Kremer%2C%20M.%2C%20Onatski%2C%20A.%2C%20%26%20Stock%2C%20J.%20%282001%29.%20Searching%20for%20prosperity.%20NBER%20Working%20Paper%20Series%2C%20Working%20Paper%208020.)

22. Lucas, R. E. (1988). The mechanism of economic development. *Journal of Monetary Economics*, *22*, 3–42. CrossRef (https://doi.org/10.1016/0304-3932(88)90168-7) Google Scholar (http://scholar.google.com/scholar_lookup?title=The%20mechanism%20of%20economic%20d

evelopment&author=RE.%20Lucas&journal=Journal%20of%20Monetary%20Economics&volume=22&pages=3-42&publication_year=1988)

23. Mikosch, T. (2009). *Non-life insurance mathematics—An introduction with the Poisson process* (2nd ed.). Berlin, Heidelberg: Springer.
    CrossRef (https://doi.org/10.1007/978-3-540-88233-6)
    Google Scholar (http://scholar.google.com/scholar_lookup?title=Non-life%20insurance%20mathematics%E2%80%94An%20introduction%20with%20the%20Poisson%20process&author=T.%20Mikosch&publication_year=2009)

24. Mittnik, S., Semmler, W., & Haider, A. (2019). *Climate disaster risks—Empirics and a multi-phase dynamic model.* IMF Working Paper WP/19/145
    Google Scholar (https://scholar.google.com/scholar?q=Mittnik%2C%20S.%2C%20Semmler%2C%20W.%2C%20%26%20Haider%2C%20A.%20%282019%29.%20Climate%20disaster%20risks%E2%80%94Empirics%20and%20a%20multi-phase%20dynamic%20model.%20IMF%20Working%20Paper%20WP%2F19%2F145)

25. Myrdal, G. (1957). *Economic theory and under-developed regions.* London: Duckworth.
    Google Scholar (http://scholar.google.com/scholar_lookup?title=Economic%20theory%20and%20under-developed%20regions&author=G.%20Myrdal&publication_year=1957)

26. Nurske, R. (1953). *Problems of capital formation n underdeveloped countries*. Oxford: Oxford University Press.
    Google Scholar (http://scholar.google.com/scholar_lookup?title=Problems%20of%20capital%20formation%20n%20underdeveloped%20countries&author=R.%20Nurske&publication_year=1953)

27. Nyberg, M., et al. (2016). A simple method to calculate first-passage time densities with arbitrary initial conditions. *New Journal of Physics*, *18*, 063019.
    CrossRef (https://doi.org/10.1088/1367-2630/18/6/063019)
    Google Scholar (http://scholar.google.com/scholar_lookup?title=A%20simple%20method%20to%20calculate%20first-passage%20time%20densities%20with%20arbitrary%20initial%20conditions&author=M.%20Nyberg&journal=New%20Journal%20of%20Physics&volume=18&pages=063019&publication_year=2016)

28. Press, W. H., et al. (2007). *Numerical recipes: the art of scientific computing* (3rd ed.). New York: Cambridge University Press.
    Google Scholar (http://scholar.google.com/scholar_lookup?title=Numerical%20recipes%3A%20the%20art%20of%20scientific%20computing&

author=WH.%20Press&publication_year=2007)

29. Quah, D. T. (1996). Twin-peaks: Growth and convergence in models of distribution dynamics. *The Economic Journal,106*, S.1045–1055. Google Scholar (https://scholar.google.com/scholar?q=Quah%2C%20D.%20T.%20%281996%29.%20Twin-peaks%3A%20Growth%20and%20convergence%20in%20models%20of%20distribution%20dynamics.%20The%20Economic%20Journal%2C106%2C%20S.1045%E2%80%931055.)
30. Rietz, T. A. (1988). The equity risk premium a solution. *Journal of Monetary Economics*, *22*(1), 117–131. CrossRef (https://doi.org/10.1016/0304-3932(88)90172-9) Google Scholar (http://scholar.google.com/scholar_lookup?title=The%20equity%20risk%20premium%20a%20solution&author=TA.%20Rietz&journal=Journal%20of%20Monetary%20Economics&volume=22&issue=1&pages=117-131&publication_year=1988)
31. Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, *98*, S71–102. CrossRef (https://doi.org/10.1086/261725) Google Scholar (http://scholar.google.com/scholar_lookup?title=Endogenous%20technological%20change&author=PM.%20Romer&journal=Journal%20of%20Political%20Economy&volume=98&pages=S71-102&publication_year=1990)
32. Rosenstein-Rodan, P. (1943). Problems of industrialization of Eastern and Southeastern Europe. *Economic Journal*, *53*, 202–211. CrossRef (https://doi.org/10.2307/2226317) Google Scholar (http://scholar.google.com/scholar_lookup?title=Problems%20of%20industrialization%20of%20Eastern%20and%20Southeastern%20Europe&author=P.%20Rosenstein-Rodan&journal=Economic%20Journal&volume=53&pages=202-211&publication_year=1943)
33. Rosenstein-Rodan, P. (1961). Notes on the theory of the big push. In H. S. Ellis & H. C. Wallich (Eds.), *Economic development in Latin America*. New York: Macmillian. Google Scholar (http://scholar.google.com/scholar_lookup?title=Notes%20on%20the%20theory%20of%20the%20big%20push&author=P.%20Rosenstein-Rodan&publication_year=1961)
34. Scitovsky, T. (1954). Two concepts of external economies. *Journal of Political Economy 62*, 143–151. Google Scholar (https://scholar.google.com/scholar?q=Scitovsky%2C%20T.%20%281954%29.%20Two%20concepts%20of%20external%20economies.%20Journal%20of%20Political%20Economy%2062%2C%20143%E2%80%93151.)
35. Semmler, W., & Ofori, M. (2007). On poverty traps, thresholds and take-offs. *Structural Change and Economic Dynamics,18*(1), 1–26. Google Scholar (https://scholar.google.com/scholar?q=Semmler

%2C%20W.%2C%20%26%20Ofori%2C%20M.%20%282007%29.%20On%20poverty%20traps%2C%20thresholds%20and%20take-offs.%20Structural%20Change%20and%20Economic%20Dynamics%2C18%281%29%2C%201%E2%80%9326.)

36. Singer, H. W. (1949). Economic progress in underdeveloped countries. *Social Research*,*15*(2).
Google Scholar (https://scholar.google.com/scholar?q=Singer%2C%20H.%20W.%20%281949%29.%20Economic%20progress%20in%20underdeveloped%20countries.%20Social%20Research%2C15%282%29.)
37. Skiba, A. K. (1978). Optimal growth with a convex-concave production function. *Econometrica*, *46*(3), 527–539.
CrossRef (https://doi.org/10.2307/1914229)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Optimal%20growth%20with%20a%20convex-concave%20production%20function&author=AK.%20Skiba&journal=Econometrica&volume=46&issue=3&pages=527-539&publication_year=1978)
38. Tarski, A. (1955). A lattice-theoretical fixpoint theorem and its applications. *Pacific Journal of Mathematics*, *5*(2), 285–309.
CrossRef (https://doi.org/10.2140/pjm.1955.5.285)
Google Scholar (http://scholar.google.com/scholar_lookup?title=A%20lattice-theoretical%20fixpoint%20theorem%20and%20its%20applications&author=A.%20Tarski&journal=Pacific%20Journal%20of%20Mathematics&volume=5&issue=2&pages=285-309&publication_year=1955)
39. Uzawa, H. (1965). Optimum technical change in an aggregative model of economic growth. *International Economic Review*, *6*, 18–31.
CrossRef (https://doi.org/10.2307/2525621)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Optimum%20technical%20change%20in%20an%20aggregative%20model%20of%20economic%20growth&author=H.%20Uzawa&journal=International%20Economic%20Review&volume=6&pages=18-31&publication_year=1965)
40. Yumashev, D., Hope, K., Schaefer, K., Riemann-Campe, F., Iglesias-Suarez, E., Jafarov, E. J., et al. (2019). Climate policy implications of nonlinear decline of Arctic land permafrost and other cryosphere elements. *Nature Communications*. Appendix: Numerical Solution Procedure.
Google Scholar (https://scholar.google.com/scholar?q=Yumashev%2C%20D.%2C%20Hope%2C%20K.%2C%20Schaefer%2C%20K.%2C%20Riemann-Campe%2C%20F.%2C%20Iglesias-Suarez%2C%20E.%2C%20Jafarov%2C%20E.%20J.%2C%20et%20al.%20%282019%29.%20Climate%20policy%20implications%20of%20nonlinear%20decline%20of%20Arctic%20land%20permafrost%20and%20other%20cryosphere%20elements.%20Nature%20Communic

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