Universidad de los Andes   *June 2007*   *Michele Boldrin*
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Topics in Growth: Innovation and Demographic Change

Outline

The purpose of this course is to discuss issues related to innovation, growth, development and demographic change. The emphasis will be on models rather than on empirical work per se. This does not mean that we will ignore empirical work or facts, in the discussion, not at all; rather, it means that these discussions will be used more for motivation of the models that we will analyze. Bottom line: in this course we study models; but motivated by some facts.

Prerequisites

Given the nature of the central topic -- innovation and demographic change-- it is natural to focus attention on dynamic models. We assume familiarity with the standard infinitely lived representative agent model of growth theory. By this we mean a basic knowledge of the issues (but not the technical details) involved in the existence of competitive equilibria (both with and without distortions), as well as the basic techniques to characterize solutions to intertemporal optimization problems (Euler equations and transversality conditions) and the equilibria they induce. Our strategy will be to use primarily discrete time models, even though some of the papers we will discuss use continuous time models.

Course Organization

There are a total of ten "meetings", each "meeting" corresponds to a three hour lecture. Plus there is a final exam. We assign homeworks randomly, sometimes on the spur of the moment (i.e. someone asks a very good question for which we do not already know the answer or an important technical detail is left out that is worth proving). We also expect you to read the papers listed in the reading list, and those suggested in class as well. The plan is the following:

Michele Boldrin: Topics 1 to 5

1. Introduction, motivation, background research in growth theory, development and motivation for so-called "new growth theory", why innovative activity is key, both theoretically and empirically. The theoretical and the policy issues behind growth theory. Where growth theory did stand before new growth theory came around (i.e. before Lucas (1988)). What was known to macroeconomists (e.g. variants of the Solow model) and what was known to economic theorists (e.g. from Von Neumman to the Turnpike literature).
2. The standard model of "new growth theory". Irrelevance of Increasing Returns per-se: reproducible goods and substitutability between reproducible and not reproducible goods.

Crucial role played by innovation in modeling growth. Existence and uniqueness of equilibrium in a model with external effects; observational equivalence with the Solow model. The role that increasing returns and externalities may play in creating indeterminacy, dependence upon initial conditions, multiple growth paths.

3. The models of Grossman-Helpman, Aghion-Howitt, Romer. Growth as due to innovation, and innovation as due to monopoly power. Implications and variations on the theme. Insights and limitations of the standard model of innovative activity based on fixed costs and increasing returns. What is logically and factually incomplete, or not satisfactory with that class of models. Building an alternative model. Ideas, public goods, external effects, social interactions, human imitations: is everything an external effect?

4. A model of innovation without increasing returns. Equilibrium under perfect competition and when the innovator is a monopolist in the first stage. Sequential Innovations. Economics of Superstars.

5. Factor-saving innovations and biased technological change. Endogenous TFP. Innovation, intellectual property and the size of the market. Trade and technological innovation.

Alice Schoonbroodt: Topics 6-10

6. *The Barro-Becker and the Boldrin-Jones Models of Endogenous Fertility*
   In this segment we study two models of endogenous fertility. The Barro-Becker model builds on altruism from parents toward children, while the Boldrin-Jones model builds on altruism from children to parents. While in the first, children are mostly a consumption good, they are an investment for old age insurance in the second. We review their implications in terms of fertility in response to changes in mortality, costs of children, technological progress, financial innovations,…

7. *Demographic Transition, Technological Progress and the Industrial Revolution*
   Using the above models as a baseline, reasearchers have included other variables and ideas – such as human capital investments, agricultural and industrial sectors, sequential fertility choices, child labor laws, compulsory schooling, various versions of a so called "quantity-quality" tradeoff and many more – to jointly address demographic change and economic development, be it from a historical perspective (the Demographic Transition and the Industrial Revolution) or from a cross-country persective. We will review various of these ideas and compare their predictions to the facts.

8. *Intergenerational Transfer Arrangements and Endogenous Fertility*
   In this section we address two popular policy issues: on the one hand, high fertility levels in underdeveloped countries and the idea that this is detrimental for growth; on the other hand, low fertility levels in developed countries and the idea that this leads to problems in terms of sustainability of social security. While we will not take a stand on whether fertility "should" be high or low, we will compare predictions of these models in terms of fertility when there are intergenerational transfers - endogenous (e.g., bequests, donations, parental support,…) and exogenous (e.g., government mandated parental support, PAYGO social security).

9. *Baby Busts and Baby Booms*

Toward the end of the Demographic Transition, almost the entire 20th century appears to constitute, for the United States and for most other developed countries, a period of unusual deviations around an otherwise declining trend in fertility. This section combines business cycle theory and endogenous fertility growth theory to address these kinds of fluctuations.

10. Fertility and Female Labor Supply
   If time allows, we will address the question how changes in fertility and female labor supply are related. In this part of the course, not only the number of children but also the timing of births are important. We will analyze how changes in fertility affect female labor supply and vice versa and how they get jointly determined given economic conditions. Furthermore, we will address the effect of female labor supply on children's cognitive ability but also children's well-being through differential spending patters between men and women.

Content

What follows is a list of useful papers. We mention lots of papers in class, and this list will allow you to look for them, should you get interested. This list is obviously **NOT** complete. Without any doubt there are famous papers (and famous authors) left out, and most certainly some of the papers we will mention are not here. In fact, even some of our recent papers are not here. We mark with a star (*) the papers we really consider fundamental contributions/required reading.

0. Background

Examples of books that contain relatively good treatments of the basic tools that we will use along with economic applications are:

Sargent, Thomas J., **Dynamic Macroeconomic Theory**, Harvard University Press.

Stokey, N. L. and R.E. Lucas (with the collaboration of E. C. Prescott), **Recursive Methods in Dynamic Economics**, Harvard University Press.

Romer, P. M., (1989), "Capital Accumulation in the Theory of Long Run Growth", in R.J. Barro (ed) **Modern Business Cycle Theory**, Harvard University Press. (It contains a very succinct introduction to dynamic methods as applied to growth models).

1.

Barro, R. J. and X. Sala-i-Martin, (1992), "Convergence," *Journal of Political Economy* **100**, No 2, 2-??.

Cass, D., (1965), "Optimum Growth in an Aggregative Model of Capital Accumulation," *Review of Economic Studies* **32**, 233-240.

(*) Dolmas, J., ``Endogenous Growth in Multisector Models'', *International Economic Review* **37**, 403-421.

Gale, D. (1960), *The Theory of Linear Economic Models*, New York: McGraw-Hill.

(*) Harberger, A.C. (1998), "A Vision of the Growth Process", *American Economic Review* **88**, 1-32.

Hayek, F. A., *The Pure Theory of Capital*, The Univ. of Chicago Press, Chicago IL (1941), reprinted by Midway Reprint, 1975. (Part III, Chapters XIX-XXV only).

Kehoe, T., D. Levine and P. Romer, ``Determinacy of Equilibria in Dynamic Models with Finitely Many Consumers'', *Journal of Economic Theory* **50**, 1-20.

(*) Koopmans, T. C., (1965), "On the Concept of Optimal Economic Growth," In **The Econometric Approach to Development Planning**, Amsterdam: North-Holland.

Lane, J.S. (1972), "The Implications of Steady State Growth for Endogenous and Embodied Technological Change," *International Economic Review* **13**, 342-358

(*) Lucas, R. E., Jr., (1988), "On the Mechanics of Economic Development," *Journal of Monetary Economics* **22**, 3-42.

McKenzie, L.W., ``Optimal Economic Growth, Turnpike Theorems and Competitive Dynamics'', in K.J. Arrow and M.D. Intriligator (eds.) *Handbook of Mathematical Economics*, vol III, North Holland Publ. C., Amsterdam--New York, 1984.

(*) McKenzie, L.W. (1998), "The Richard Ely Lecture. Turnpikes," *American Economic Review Papers and Proceedings* **88**, (May 1998), 1–14.

(*) Neumann, J. von (1945), 'A model of general economic equilibrium', *Review of Economic Studies*, **13**, 1–9. English translation of 'Über ein ökonomisches Gleichungssystem und eine Verallgemeinerung des Brouwerschen Fixpunktsatzes', in *Ergebnisse eines mathematischen Kolloquiums* **8** (1937), 73–83.

Pasinetti, L., *Structural Change and Economic Growth,* Cambridge Univ. Press, Cambridge, 1981.

Schumpeter, J., *The Theory of Economic Development*, Harvard Univ. Press, Cambridge, MA, 1934, (1st German edition: 1911).

Shell, K., (1967), "A Model of Inventive Activity and Capital Accumulation," in, Shell, Ed., **Essays in the Theory of Optimal Economic Growth**, MIT Press: Cambridge, MA.

Shell, K., (1973), "Inventive Activity, Industrial Organization and Economic Growth," in **Models of Economic Growth**, J. A. Mirrlees and Nicholas Stern, Eds., London:Macmillan.

(*) Solow, R. M., (1956), "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Economics* **70**, 65-94.

(*) Solow, R. M., (1957), "Technical Change and the Aggregate Production Function," *The Review of Economics and Statistics* **39**, 312-320

Solow, R.M., (1960), "Investment and Technical Progress," in K.J. Arrow et al. (eds.) *Mathematical Methods in the Social Sciences*, Stanford Univ. Press, Stanford, CA.

Solow, R.M. et al., (1966), "Neoclassical Growth with Fixed Factor Proportions", *Review of Economic Studies* **33**, 79-115.

2.

(*) Aghion, P. and P. Howitt, (1992), "A Model of Growth Through Creative Destruction," *Econometrica* **60**, 323-351.

Arrow, K., (1962), "The Economic Implications of Learning by Doing," *Review of Economic Studies* **29**, 155-173.

Arrow, K.J. (1998), 'Innovation and increasing returns to scale', in K.J. Arrow, Y-K. Ng, and X. Yang (eds), *Increasing Returns and Economic Analysis*, London: Macmillan, pp. 403–8.

Arthur, W. Brian (1989), "Competing Technologies, Increasing Returns, and Lock-In by Historical Events," *The Economic Journal* **99**, 116-131.

Benhabib, J. and R. Perli (1994), 'Uniqueness and indeterminacy: on the dynamics of endogenous growth', *Journal of Economic Theory* **63**, 113–42.

(*) Boldrin, M. and A. Rustichini, ``Growth and Indeterminacy in Dynamic Models with Externalities'', *Econometrica* **62**, 323-342.

Boldrin, M. and J. Scheinkman. (1988) "Learning by Doing, International Trade and Growth: A Note" in P.Anderson et al. (eds.) *The Economy as an Evolving Complex System*, New York, Addison Wesley, 1988.

Brozen, Y. (1951), "Invention, Innovation and Imitation," *The American Economic Review Papers & Proceedings* **41** (May), 239-257.

Caballero, R. and M. Hammour (1994), ``The Cleansing Effect of Recessions'', *American Economic Review* **84**, 1350-1368.

Dixit, A. and J. Stiglitz (1977), 'Monopolistic competition and optimum product diversity', *The American Economic Review* **67**, 297–308.

Grossman, G. M. and E. Helpman, (1991), **Innovation and Growth in the Global Economy**, MIT Press. Various Chapters

(*) Grossman, G. and E. Helpman, (1991), "Quality Ladders in the Theory of Growth," *Review of Economic Studies* 5**8**, 43-61.

(*) Jones, L. E. and Manuelli, R.E., (1990), "A Convex Model of Equilibrium Growth: Theory and Policy Implications," *Journal of Political Economy* **98**, 1008-38.

(*) Kortum, S.S. (1997), 'Research, patenting and technological change', *Econometrica* **65**, 1389–419.

(*) Lucas, R. E., Jr., (1988), "On the Mechanics of Economic Development," *Journal of Monetary Economics* **22**, 3-42.

Matsuyama, K. (1991), "Increasing Returns, Industrialization, and Indeterminacy of Equilibrium," *The Quarterly Journal of Economics* **106**, 617-650.

Nelson, R.R. (1996), *The Source of Economic Growth*, Cambridge, Massachusetts: Harvard University Press.

(*) Romer, P. M., (1990), "Are Nonconvexities Important for Understanding Growth?," *The American Economic Review Papers & Proceedings* **80** (May), 97-103.

(*) Romer, P. M., (1986), "Increasing Returns and Long Run Growth," *Journal of Political Economy* **94**, 1002-37.

Romer, P. M., (1987), "Growth Based on Increasing Returns due to Specialization," *The American Economic Review Papers & Proceedings* **77** (May), 56-62.

(*) Romer, P. M., (1990), "Endogenous Technological Change," *Journal of Political Economy* **98**, S71-S102.

Segerstrom, P., (1991), "Innovation, Imitation, and Economic Growth," *Journal of Political Economy* **99**, 807-827.

Shell, K., (1967), "A Model of Inventive Activity and Capital Accumulation," in, Shell, Ed., *Essays*

in the Theory of Optimal Economic Growth, MIT Press: Cambridge, MA.

Shell, K., (1973), "Inventive Activity, Industrial Organization and Economic Growth," in *Models of Economic Growth*, J. A. Mirrlees and Nicholas Stern, Eds., London:Macmillan.

(*) Stokey, N. L., (1988), "Learning by Doing and the Introduction of New Goods," *Journal of Political Economy* **96**, 701-717.

(*) Uzawa, H., (1965), "Optimum Technical Change in an Aggregative Model of Economic Growth," *International Economic Review* **6**, 18-31.

Young, A., (1993), "Invention and Bounded Learning by Doing," *Journal of Political Economy* **101**, 443-472.

3.
(*) Arrow, K.J. (1962), "Economic Welfare and the Allocation of Resources for Invention,", in Richard Nelson (ed.), *The Rate and Direction of Inventive Activity,* Princeton, NJ: Princeton University Press.

Acemoglu, D. and F. Zilibotti, (1997), "Was Prometheus Unbound by Chance? Risk, Diversification, and Growth," *Journal of Political Economy* **105,** 709-751

(*) Aghion, P., C. Harris, P. Howitt and J. Vickers, Jul., (2001), "Competition, Imitation and Growth with Step-by-Step Innovation" *Review of Economic Studies* **68**, 467-492.

Benoit, J.P., (1985), "Innovation and Imitation in a Duopoly," *Review of Economic Studies* **52**, 99–106.

Boldrin, M. and D. Levine, (1997)``Growth Under Perfect Competition. Homogeneous Agents'', mimeo, available on line at www.econ.umn.edu/~mboldrin.html

(*) Boldrin, M. and D. Levine, ``Perfectly Competitive Innovation'', mimeo, various versions, 1997-2005, available on line at www.econ.umn.edu/~mboldrin

Marshall, A. (1890), *Principles of Economics*, 8th edn, 1920. Reprint, London: Macmillan, 1977.

4.
Acemoglu, D. (2001), "Directed Technical Change," NBER working paper no. 8287.

Aghion, P. and P. Howitt, "Growth and Unemployment", *Review of Economic Studies* **61**, 477-494.

(*) Boldrin, M. and J. Fernandez Villaverde (2005), "A Theory of Growth Cycles,", mimeo,

available on line at www.econ.umn.edu/~mboldrin

(*) Boldrin, M. and D.K. Levine (2002), "Factor Saving Innovation", *Journal of Economic Theory* **105,** 18-41.

(*) Boldrin, M. and D.K. Levine, "Innovation and the Size of the Market", mimeo, Univ of Minnesota and UCLA, April 2004, available on line at www.econ.umn.edu/~mboldrin

Caballero, R. and M. Hammour, (1994), "The Cleansing Effect of Recessions," *American Economic Review* **84,** 1350-1368.

Cooley, T. and E. Prescott, ``Economic Growth and Business Cycles'' in T. Cooley *Frontiers of Business Cycle Research*, Princeton Univ. Press, Princeton, NJ, 1995.

Corriveau, L., (1994), "Entrepreneurs, Growth and Cycles," *Economica* **61,** 1-15.

David, Paul (1975), *Technical choice, innovation and economic growth*. Cambridge: Cambridge University Press.

Goodwin, R.M. (1946), "Innovations and the irregularity of economic cycles", *Review of Economic Statistics* **28**, 95–104.

Grossman, G. and E.L.-C. Lai, (2002), "International Protection of Intellectual Property,"NBER Working Papers 8704; see revised version, mimeo, 2004, in Grossman's website.

(*) Helpman, E. (1993), "Innovation, Imitation, and Intellectual Property Rights," *Econometrica* **61**, 1247-1280.

(*) Krugman, P., (1979), "A Model of Innovation, Technology Transfer, and the World Distribution of Income," *Journal of Political Economy* **87**, 253-266.

Matsuyama, K. (1999), "Growing Through Cycles," *Econometrica* **67**, 335-347.

(*) Rivera Batiz, L. and P. Romer, (1991), "Economic Integration and Endogenous Growth," *Quarterly Journal of Economics* **106**, 531-555.

Shell, K. et al., (2000), "The Production Recipe Approach to Modeling Technological Innovation: An Application to Learning by Doing," *Journal of Economic Dynamics and Control* **24**, 389-450.

Weitzman, M.L., (1998), "Recombinant Growth," *Quarterly Journal of Economics* **CXIII**, 331-360.

Young, A. (1991), "Learning by Doing and the Dynamic Effects of International Trade," *Quarterly Journal of Economics* CVI, 369-406.

6. The Barro-Becker and the Boldrin-Jones Models of Endogenous Fertility

Alvarez, F., (1999), "Social Mobility: The Barro-Becker Children Meet the Laitner-Loury Dynasties," *Review of Economic Dynamics*, 2(1): 65-103.

(*) Barro, R.J. and G.S. Becker, (1989), "Fertility Choice in a Model of Economic Growth," *Econometrica* **57**, 481-501.

(*) Becker, G.S. and R.J. Barro (1988), "A Reformulation of the Economic Theory of Fertility", *Quarterly Journal of Economics* **103**, 1–25.

(*) Boldrin, M. and L. Jones, (2002), "Mortality, Fertility and Savings in a Malthusian Economy," *Review of Economic Dynamics* **5**, 775-814

7. Demographic Transition, Technological Progress and the Industrial Revolution

Bar, M. and Leukhina, O., (2005), "A Model of Historical Evolution of Output and Population," working paper, University of North Carolina.

Becker, G., Murphy, K. M. and R. Tamura, (1990), "Human Capital, Fertility and Economic Growth," *Journal of Political Economy*, Vol. 98, No. 5, Part 2, S12-S37, October

Boldrin, M., and L. Jones (2004), "Three Equations Generating an Industrial Revolution", mimeo, University of Minnesota, available on line at www.econ.umn.edu/~mboldrin

De la Croix, D. and Doepke, M., (2003), "Inequality and Growth: Why Differential Fertility Matters," *American Economic Review*, 93, (4): 1091--1113.

Doepke, M., (2004), "Accounting for Fertility Decline During the Transition to Growth," *Journal of Economic Growth*, 9(3): 347--383.

Doepke, M., (2005), "Child Mortality and Fertility Decline: Does the Barro-Becker Model Fit the Facts?," *Journal of Population Economics*, 18: 337-366.

Fernandez-Villaverde, Jesus, (2001), "Was Malthus Right? Economic Growth and Population Dynamics", available on line at

Galor, O. and D.N. Weil (1999), "From Malthusian stagnation to modern growth", *American Economic Review*, **89**, 150–4.

Galor, O. and Weil, D. N., (2000), "Population, Technology, and Growth: From

Malthusian Stagnation to the Demographic Transition and Beyond," *American Economic Review*, 90 (4): 806--28.

Greenwood, J. and Seshadri, A., (2002), "The U.S. Demographic Transition," *American Economic Review Papers and Proceedings*, 92 (2): 153--159.

Hansen, G.D. and E.C. Prescott (1999), *From Malthus to Solow*, Federal Reserve Bank of Minneapolis, Research Department Staff Report 257.

Lucas, R. E. Jr., (2002), "Industrial Revolution: Past and Future," in *Lectures on Economic Growth*, Cambridge: Harvard University Press.

8. Intergenerational Transfer Arrangements and Endogenous Fertility

(*) Boldrin, M., M.C. DeNardi, and L. Jones (2004), "Fertility and Social Security", mimeo, University of Minnesota, available on line at www.econ.umn.edu/~mboldrin

(*) Ehrlich, I. and Lui, F., (1991), "Intergenerational Trade, Longevity, Intrafamily Transfers and Economic Growth," *Journal of Political Economy* **99**, 1029-59.

Kremer, M., (1993), "Population Growth and Technological Change: One Million B.C. to 1990," *Quarterly Journal of Economics* **CVIII**, 681-716.

Neher, P.A. (1971), "Peasants, Procreation and Pensions," *American Economic Review* **61**, 380-389.

Razin, A. and U. Ben-Zion (1974), "An Intergenerational Model of Population Growth," *American Economic Review* **65**, 923-933.

Rosenzweig, M. R., (1990), "Population Growth and Human Capital Investments: Theory and Evidence," *Journal of Political Economy* **98**, S38-S70.

9. Baby Busts and Baby Booms

Boldrin, M., L. E. Jones, and A. Schoonbroodt (2006a). "Baby busts and baby booms: The fertility response to shocks in dynastic models." Working Paper, University of Minnesota.

Boldrin, M., L. E. Jones, and A. Schoonbroodt (2006b). "Baby busts and baby booms: A cross-country study of fertility responses to depressions and war capital build-ups." Working Paper, University of Minnesota.

Butz, William P. Butz and Michael P. Ward, (1979), \The Emergence of Countercyclical U.S. Fertility" *American Economic Review*, 69(3), pp. 318-328.

Easterlin, R. A. (2000). Twentieth-century american population growth. In S. L. Engerman and R. E. Gallman (Eds.), The Cambridge Economic History of the United States, Volume 3: The Twentieth Century, pp. 505–48. Cambridge University Press, Cambridge, MA.

Greenwood, J., A. Seshadri, and G. Vandenbroucke (2005). "The baby boom and baby bust." *American Economic Review 95* (1), 183–207.

10. Fertility and Female Labor Supply

Bernal R.. "The effect of maternal employment and child care on children's cognitive development." Working Paper, Northwestern University, 2004.

Caucutt Elizabeth M., Nezih Guner, and John Knowles. "Why do women wait? Matching, wage inequality, and the incentives for fertility delay." *The Review of Economic Dynamics*, 5(4):815–855, oct 2002.

Erosa Andres, Luisa Fuster, and Diego Restuccia. "A quantitative theory of the gender wage gap in wages." Working Paper, University of Toronto, 2005.

Francesconi Marco. "A joint dynamic model of fertility and work of married women" *Journal of Labor Economics*, 20(2):336–380, 2002.

Galor Oded and David N. Weil. "The gender gap, fertility and growth." *American Economic Review*, 86(3):374–87, June 1996.