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The Transitional Dynamic of Finance Led Growth

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Abstract

We depart from the empirical literature on testing the *finance led growth*. Instead of regression analysis, we use a semi-endogenous growth model, which identifies two productivity growth paths: a steady state and a transitional path. Steady state growth is anchored by population growth. In the transitional dynamic, productivity growth depends on the typical factors growth rates, and *excess knowledge,* which is the deviation of TFP in the financial sector from steady state growth. TFP is endogenous. It is an increasing function of *global research efforts,* which is driven by the proportion of population in *developed countries* that is engaged in research in finance, and the stock of human capital. We find positive evidence for this theory of TFP in the data of ten developed European countries and the United States, and some evidence for finance-led-growth.

JEL Classification Numbers O40, E10

Keywords: Semi endogenous growth, finance, productivity growth

1. Introduction

The literature on the relationship between finance and growth is old and voluminous. Levine (1997), Eschenbach (2004), Trew (2005), and Ang (2008), are the most important surveys of the literature.[i]

In theory, financial development affects economic growth via two channels. First is the capital accumulation.[ii] Second is the technical progress, where innovative financial technologies lessen information-asymmetries, which adversely affect efficient allocations of savings and the monitoring of investment projects. See for example, Greenwood and Javanovic (1990), and King and Levine (1993 b).

Generally, the theory is tested empirically using either cross-sectional or time-series regressions. Details of modeling the finance-led-growth relationship, whether in cross-sectional or time-series data, are subject to a number of specification and estimation problems. Ang (2008) provides a comprehensive description.

We are concerned with the explanatory variables that are usually used as proxies for financial development. In aggregated data, variables such as the ratios of M2/GDP and bank credit / GDP are typical proxies. The issue of long run money neutrality (and perhaps super-neutral) has been contentious, see Lucas (1996) Nobel Lecture for example. Since growth is a long-run phenomenon, "money cause growth" is not a universally acceptable argument. However, most economists agree that money and credit expansions cause real output to increase above its long-run potential level over the business cycle because of observed price and wage stickiness in the short run.

In addition and most importantly is that there are a number of arguments against the use of money and credit ratios as proxies for financial development. Gurley and Shaw (1955), for example, argue that they might be good proxies for financial development in *developing countries*, where banks provide lending and transaction services. However, they are not so in more advanced economies with financial innovations, where money plays a less important role. A high ratio of money and credit to GDP may not be a sign of financial development since it has been observed that they increase before financial crisis. More papers cast doubt on the robustness of the finance and growth relations.[iii]

In this paper, we do not use proxies such money and credit ratios to test the finance led growth hypothesis. Essentially, we test whether technical progress – Total Factor Productivity (TFP) – in the financial sector instead, drives productivity growth. Essentially, knowledge is the driver of growth.

The idea that *useful* or *testable knowledge* is the primary driver of per capital growth belongs to Simon Kuznets (e.g., 1960). In Kuznets, population growth in *developed countries* (not in developing countries) increases the proportion of people engaged in scientific research that drives per capita output growth. Technical progress, whether in the economy in general or in a particular sector of the economy, is the product of scientific research. Thus, TFP is endogenous. See Kremer, M. (1993) for an empirical support for Kuznets' theory. He provided evidence that countries with larger initial populations have had faster technological change and population growth.

Jones (2002) growth model encapsulates Kuznets idea (without citing him). It is a semi-endogenous endogenous growth model, whereby he distinguished between a *constant growth path* and a *balanced growth path*. Along both paths, growth rates are constant. However, as investments, skills, knowledge, and research increase they generate *a transition path growth effect* and *a level effect* on income. Per capita growth could settle down at a constant rate that is higher than its long-run rate. As investments in research stop growing and the fraction of time that individuals spend accumulating skills and knowledge and the share of the labor force devoted to research level off, the economy's growth rate gradually decline to its long-run rate. This is also consistent with Nelson, R. and Phelps, E. (1966), who tested the hypothesis that educated people make good innovators, so that education speeds up the process of technological diffusion.

We modify Jones (2002) to allow for sectors' effect on growth. Simply, we assume TFP in the financial sector is proportional to the economy-wide TFP. Thus, the steady state depends on population growth (labor force growth). For the transitional dynamic path, the economy-wide productivity growth depends on factor inputs growth rates, i.e., the growth rates of the capital-output ratio, the stock of human capital, and labor, and on *excess knowledge*, which is the deviation of TFP in the financial sector from the steady state growth rate. Essentially, productivity growth increases when TFP growth (in general and in the financial sector, or any other sector) exceeds population growth.

We found, first, that the time series – cross sectional data for ten European advanced economies and the United States fit the Jones (2002) model very well. The time series samples T are from the mid 1990s to 2015 although individual country's data vary in length (see the data appendix), and $N = 11$.

The model explains productivity growth *differentials*. Excess knowledge differential (the gap between excess knowledge in the United States and any $i = 1 \dots N$ country) explains 80 percent of the productivity growth differential between the United States and any other country. The rest is explained by the capital-output ratio growth differential, human capital growth differential, and labor growth differential. Essentially, productivity growth differentials across advanced countries boil down, mostly, to technology gaps relative to population growth gaps. However, since population growth rates in advanced Western countries are very small, most of the productivity growth differentials are explained by technology gap.

Second, we find a reasonably positive and strong relationship between global research effort in the financial sector, which depends on human capital and the number of people engaged in research, and TFP in the financial sectors. Thus, the theory of endogenous TFP in this set up can be confirmed by the data.

Finally, excess knowledge in the financial sector is correlated with the economy-wide productivity growth albeit the correlation is weakened by recessions and financial crises such as the Asian financial crises, global financial crisis and the Great recession.

Next, we describe the model. We derive a relationship between long-run productivity growth and TFP in the financial sector, which is driven by discoveries of global new research ideas in finance.[iv]

In section 3, we provide measurements and analysis of growth accounting. Section 4 is conclusions.

1. The model

In each economy in the world, output is produced by the following Cobb-Douglas production function:

$$Y_t = A_t^{\sigma} K_t^{\alpha} H_{Y_t}^{1-\alpha} \,, \quad (1)$$

where K_t is physical capital, $H_{Y_t}$is the total quantity of human capital employed to produce output Y_t andA_t is the accumulating stock of *ideas* or *knowledge* created in the World. It is assumed that $0 < \alpha < 1$ and $\sigma > 0$, which implies a constant return to scale in K and H_Y and an increasing return to scale in K, H_Y and A as $\alpha + 1 - \alpha + \sigma = 1 + \sigma > 1$.

Let us assume that the stock of knowledge in finance A_{F_t} (subscript Fdenotes finance):

$$A_{F_t} = \eta_0 A_t^{\eta} \text{ , where} \eta > 0, \quad (2)$$

It means that the stock of knowledge in finance is proportional to the overall stock of knowledge in the economy.

In log:

$$log(A_{F_t}) = log(\eta_0) + \eta \, log(A_t). \quad (3)$$

The growth rate is:

$$g_{A_F} = \eta . g_A, \quad (4)$$

from (2) we get,$A_t = \eta_0^{-\frac{1}{\eta}} A_{F_t}^{\frac{1}{\eta}}$, (2`)

Substituting the stock of knowledge in finance in the production function, we get:

$$Y_t = \eta_0^{\frac{-\sigma}{\eta}} A_{F_t}^{\frac{\sigma}{\eta}} K_t^{\alpha} H_{Y_t}^{1-\alpha} \quad (5)$$

Now we describe each element of the production function.

First, physical capital accumulates as:

$$\dot{K}_t = s_{K_t} Y_t - dK_t, \quad K_0 > 0 \quad (6)$$

Where a dot over the variable denotes the growth rate and $s_{K_t}$is the fraction of output that is invested, and $d > 0$is the constant depreciation rate.[v]

The aggregate human capital used in the production of output is:

$$H_{Y_t} = h_t L_{Y_t},\tag{7}$$

Where, $L_{Y_t}$is the number of workers who produce output and,

$$h_t = e^{\varphi \ell_{ht}}\tag{8}$$

is the human capital per person in which ℓ_{ht} is the time spent in accumulating capital (average years of schooling), where $\phi$is the rate of returns to education as in Mincer (1974).[vi]

The final element in the production function of output is the stock of knowledgeA_t. The countries in this model share ideas and knowledge (there are no trade in goods and services in this model). Ideas and knowledge created anywhere in the world are potentially available to be used in any other economy, i.e. non-rivalry and non-excludability. It follows that A_t corresponds to the cumulative stock of knowledge created anywhere in the world and is common to all economies.

$$\dot{A}_t = \delta H_{A_t}^{\lambda} A_t^{\varphi} \quad A_0 > 0,.\tag{9}$$

Let A_{F_t}be the knowledge in the financial sector; the *effective world research effort* in the financial sector as a fixed proportion from the entire global research effort $H_{A_t}H_{A_t}$, where

$$H_{A_{F_t}} = \varepsilon H_{A_t}; 0 \leq \varepsilon \leq 1,\tag{10}$$

where $H_{A_t} = \sum_{i=1}^{M} h_{it}^{\theta} L_{A_{it}}.L_{A_{it}}$is the number of researchers in economy i.[vii] Note that here we have a subscript i. The index i refers to the economies i to M. Jones (2002) assumes that global research is the weighted sum of research conducted in the five advanced countries: US, UK, Germany, France and Japan (i.e., $M = 5$) and assumes that $\theta \geq 0$, which means that the quality of research is constant across these five countries. We use all 11 countries in the sample for M.

Let$L_{A_{Fit}} = a_i L_{Ait}; \quad 0 \leq a_i \leq 1$, then ,

$$H_{A_{F_t}} = \varepsilon \sum_{i=1}^{M} h_{it}^{\theta} \left(\frac{L_{A_{Fit}}}{a_i}\right),\tag{11}$$

where $L_{A_{Fit}}$is the number of researchers in the financial sector only in a given economy i.

From (2`):

$\dot{A}_t = \frac{1}{\eta}\dot{A}_{F_t}$, considering this and equation (10) and substituting in (9),

$$\frac{1}{\eta}\dot{A}_{F_t} = \delta\left(\frac{1}{\varepsilon}H_{A_{F_t}}\right)^{\lambda}\left(\eta_0^{-\frac{1}{\eta}}A_{F_t}^{\frac{1}{\eta}}\right)^{\phi}$$

So $\dot{A}_{F_t} = (\eta\delta\varepsilon^{-\lambda}\,\eta_0^{\frac{-\phi}{\eta}})H_{AF_t}^{\lambda}A_{F_t}^{\frac{\phi}{\eta}}$

Simply, $\dot{A}_{F_t} = \mu H_{A_{F_t}}^{\lambda}A_{F_t}^{\frac{\varphi}{\eta}}$, where $\mu = \eta\delta\varepsilon^{-\lambda}\,\eta_0^{\frac{-\phi}{\eta}}$ (12)

The number of new ideas (knowledge) produced at any point in time depends on the number of researchers and existing stock of ideas. Jones (2002) allows $0 < \lambda \leq 1$capturing the possibility of duplication in research, i.e., a doubling of the number of researchers produces less than a doubling of the number of ideas. Jones also assumes that $\phi < 1$. There is also a binding resource constraint on labor. Each economy is populated by, N_t, identical, infinitely lived agents. The number of agents in each economy grows over time at a common and exogenous rate $n > 0$:

Population grows at natural rate n as follows:

$$N_t = N_0 e^{nt}, N_0 > 0 \tag{13}$$

Because the time spent in school is excluded from labor force data, the labor constraints imply that each individual is endowed with one unit of time, divided among the production of goods, ideas, and human capital:

$$L_t = L_{A_t} + L_{Y_t} = \frac{1}{b}L_{AFt} + L_{Y_t} = (1-\ell_{ht})N_t\ , \tag{14}$$

where, ℓ_{ht} is the time spent producing human capital and $L_{AFt} = bL_{A_t}$ the number of researchers creating ideas and knowledge in the financial sector in the world as a part of L_{A_t}, $0 < b < 1$.

Let $y_t = \frac{Y_t}{L_t}$ the output per worker, $L_{Y_t} = H_{Y_t}/h_t$ and $\ell_{Y_t} = \frac{L_{Y_t}}{L_t}$

we get:

$$y_t = \frac{Y_t}{L_t} = \frac{Y_t}{L_{Y_t}} . \frac{L_{Y_t}}{L_t} = \frac{\eta_0^{\frac{-\sigma}{\eta}} A_{F_t}^{\frac{\sigma}{\eta}} K_t^{\alpha} H_{Y_t}^{1-\alpha}}{H_{Yt}/h_t} \ell_{Y_t} = \ell_{Y_t} h_t \eta_0^{\frac{-\sigma}{\eta}} A_{F_t}^{\frac{\sigma}{\eta}} K_t^{\alpha} H_{Y_t}^{-\alpha} \quad (15)$$

Then from $Y_t = \eta_0^{\frac{-\sigma}{\eta}} A_{F_t}^{\frac{\sigma}{\eta}} K_t^{\alpha} H_{Y_t}^{1-\alpha}$ we get:

$$H_{Y_t}^{-\alpha} = Y_t^{-\alpha/(1-\alpha)} \eta_0^{\frac{-\alpha}{\eta(1-\alpha)}\sigma} A_{Ft}^{\frac{\alpha}{\eta(1-\alpha)}\sigma} K_t^{\frac{\alpha^2}{(1-\alpha)}} \quad (16)$$

Substituting in $y_t$and simplifying, we get:

$$y_t = \ell_{Y_t} h_t \eta_0^{\frac{-\sigma}{\eta(1-\alpha)}} A_{F_t}^{\frac{\sigma}{\eta(1-\alpha)}} \left(\frac{K_t}{Y_t}\right)^{\frac{\alpha}{1-\alpha}} \quad (17)$$

Solving for A_{F_t} we have

$$A_{F_t} = \frac{\eta_0 y_t^{\eta\frac{1-\alpha}{\sigma}}}{\left(\frac{K_t}{Y_t}\right)^{\eta\frac{\alpha}{\sigma}} (\ell_{Y_t} h_t)^{\eta\frac{1-\alpha}{\sigma}}} \quad (18)$$

From (12), $\dot{A}_{F_t} = \mu H_{A_{F_t}}^{\lambda} A_{F_t}^{\frac{\varphi}{\eta}}, A_{F_0} > 0$ we have:

$$g_{A_F} = \frac{\dot{A}_{Ft}}{A_{F_t}} = \mu . H_{A_{F_t}}^{\lambda} A_{F_t}^{\frac{\varphi-\eta}{\eta}} . \quad (19)$$

Or also;

$$A_{F_t} = (\mu/g_{A_F})^{\frac{\eta}{\eta-\varphi}} H_{A_{F_t}}^{\frac{\eta}{\eta-\varphi}\lambda} . \quad (20)$$

So:

$$A_{F_t}^{\frac{\sigma}{1-\alpha}} = (\mu/g_{A_F})^{\frac{\eta}{(\eta-\varphi)}\frac{\sigma}{(1-\alpha)}} H_{A_{F_t}}^{\frac{\lambda\eta}{(\eta-\varphi)}\frac{\sigma}{(1-\alpha)}}. \quad (21)$$

By defining $\gamma = \frac{\lambda}{(\eta-\varphi)} \frac{\sigma}{(1-\alpha)}$, we have:

$$A_{F_t}^{\frac{\sigma}{1-\alpha}} = (\mu/g_{A_F})^{\frac{\gamma}{\lambda}\eta} H_{A_{F_t}}^{\gamma\eta}. \quad (22)$$

From accumulating capital equation$\dot{K}_t = s_{K_t} Y_t - dK_t, K_0 > 0$ we get

$$g_k = \dot{K}_t - \dot{L}_t = s_{K_t}.(Y_t/K_t) - (d+n), \tag{23}$$

which gives:

$$K_t/Y_t = \frac{s_{K_t}}{g_k+d+n}, \tag{24}$$

where g_k is the *constant* growth rate of *k=K/L*. Given equations (17), (22), and (24), we get:.

$$y_t = \eta_0^{\frac{-\sigma}{\eta(1-\alpha)}} \ell_{Y_t} h_t \left(\frac{\mu}{g_{A_{Ft}}}\right)^{\frac{\gamma}{\lambda}} \left(\frac{s_{Kt}}{g_k+d+n}\right)^{\frac{\alpha}{1-\alpha}} H_{A_{Ft}}^{\gamma} \tag{25}$$

The stock of capital K and A_F grow at *constant rates*, which require H_{A_F} growing also at a *constant rate* (asterisk over variables mean that they grow at constant rate) we have:

$$y_t = \eta_0^{\frac{-\sigma}{\eta(1-\alpha)}} \left(\frac{s_{Kt}^{*}}{g_k+d+n}\right)^{\frac{\alpha}{1-\alpha}} \ell_{Y_t} h_t \left(\frac{\mu}{g_{A_F}}\right)^{\frac{\gamma}{\lambda}} H_{A_{Ft}}^{*\gamma} \tag{26}$$

On a balanced growth path, all variables grow at constant rate and the allocations must be constant. From equation (17) we get:

$$g_y = \frac{\sigma}{\eta(1-\alpha)} g_{A_F} \,. \tag{27}$$

Also from $A_{F_t}^{\frac{\sigma}{1-\alpha}} = (\mu/g_{A_F})^{\frac{\gamma}{\lambda}\eta} H_{A_{F_t}}^{\gamma\eta}$ we arrive at the steady-state equation:

$$\frac{\sigma}{1-\alpha} g_{A_F} = \gamma\eta . g_{H_{A_F}}, \tag{28}$$

where g denotes the growth rate. Finally, since h (human capital per person) must be constant along the steady state path, growth in the effective number of world researchers in the financial sector $H_{A_{F_t}}$ is driven by population growth, so:

$$g_{H_{A_F}} = n, \tag{29}$$

then:

$$g_y = \frac{\sigma}{\eta(1-\alpha)} g_{A_F} = \gamma n \tag{30}$$

Taking log and differentiating, $y_t = \ell_{Y_t} h_t \eta_0^{\frac{-\sigma}{\eta(1-\alpha)}} A_{F_t}^{\frac{\sigma}{\eta(1-\alpha)}} \left(\frac{K_t}{Y_t}\right)^{\frac{\sigma}{1-\alpha}}$, and add and subtract the steady-state term, γn, we get the growth accounting equation:

$$\dot{y}_t = \left[\frac{\alpha}{1-\alpha}\left(\dot{K}_t - \dot{Y}_t\right) + \dot{h}_t + \dot{\ell}_{Y_t} + \left\{\frac{\sigma}{\eta(1-\alpha)}\dot{A}_{F_t} - \gamma n\right\}\right] + \gamma n \quad (31)$$

The terms in squared brackets are *the transitional dynamic*. The term in curly brackets is *excess knowledge*, and the last term is the steady state. A dot on the top of the variable denotes the average change in the log of a variable between two points in time. Excess knowledge in finance, which is a function of TFP in the financial sector and driven by global research efforts in finance, cause productivity growth. From (2), TFP in the financial sector must be growing faster than the economy-wide TFP. The last term γn represents the steady-state growth, while all other terms represent the transitional dynamic of the growth process.

Jones (2002) original growth equation was given by:

$$\dot{y}_t = \left[\frac{\alpha}{1-\alpha}\left(\dot{K}_t - \dot{Y}_t\right) + \dot{h}_t + \dot{\ell}_{Y_t} + \left\{\frac{\sigma}{(1-\alpha)}\dot{A}_t - \gamma n\right\}\right] + \gamma n \quad (32)$$

Next, we test the correlations between productivity growth, and each of the components of the transitional dynamic.

1. Measurements

We use EUKLEMS recent data set to measure productivity growth $\dot{y}_t$ for 11 countries advanced economies from 1995 – 2015. The countries are Austria, Belgium, Finland, France, Germany, Italy, the Netherlands, Spain, Sweden, the U.K. and the U.S. The data are in the data appendix.

EUKLEMS provide a *market* measure for all the variables. It removes certain sectors, where output is hard to measure such as services, and the government etc. See the data appendix for the excluded sectors. We use the market measure.

We define productivity as real output per hours worked. For real output put we use value added measure (VA), which we deflate by the value added price, VA_P (2010=100). We then measure real value added per hours worked by dividing the real value added by total hours by persons – engaged (H_EMP). Then we compute the growth rate by log – differencing the data.

For the stock of capital – GDP ratio, we use the EUKLEMS data for the stock of capital in the market economy to the real value added.

The data for labor are hours-worked in the market sectors.

For excess knowledge in the financial sector, $\frac{\sigma}{\eta(1-\alpha)}\dot{A_{F_t}}$ we use the sector's *market* measures of TFP as reported in EUKLEMS to measure $\dot{A_{F_t}}$, the growth rate, which is the log – difference. We have three ways to estimate the parameter η; in equation (2, 2` and 3). First is by the ratio of $\frac{\log(A_{Ft})}{\log(A_t)}$, assuming $\log(\eta_0) = 0$; second is by a linear time series OLS regression of equation (3); and finally by a cross sectional regression (recall that N=11) with cross-section weights and heteroscedastic standard errors. The Penn World Table 9.0 reports time series for the share of labor so it is $1-\alpha$ in equation (4). We take the average value over the samples. However, the parameter σ is unidentifiable. Jones (2002) assumed that it is equal to$1-\alpha$ so that A is measured in units of Harrod-Neutral productivity. We use sensitivity analysis and calibrate the equation using a number of values. We find $\sigma=1$provide the best fit for every country in the sample.

For the second term in excess knowledge is steady state growth, γn, Jones (2002) suggested that the value for the U.S. is between 0.05 and 0.30. He argued that the parameter γ de-trends the ratio H_{At}^{γ}/A_t, i.e., to render TFP growth rate stationary. Therefore, the parameter γ is approximately equal to the ratio $\dot{H}_{At}/\dot{A}_t$.

To measure γ we need to measure $\dot{H}_{A_t}$ first. It's level given by $H_{A_t} = \sum_{i=1}^{M} h_{it}^{\theta} L_{A_{it}}$, $i = 1 \dots . N$. The human capital index h_t is from the Penn World Table 9.0; it varies significantly over time. The World Bank reports number of researchers by country, but the time series has missing years across the panel. For this reason, we calculate $H_{At}$for each country i for the year 1995 and the year 2014 only (two observations only) then the growth rate over that range. The value of the weight θ did not seem to matter for the computation of γ. We tried a value of zero, one, and the share of the number of researchers in each country in the total number of researcher in these 11 countries. The growth rate, $\dot{H}_{At}$ did not change significantly. We set θ to one.

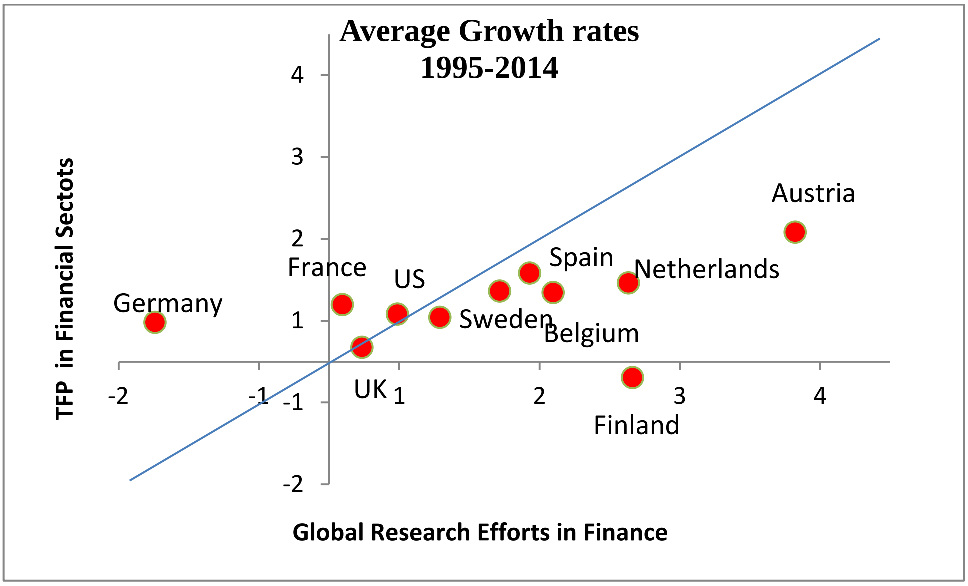
For the economy-wide excess knowledge, we use the *market economy* data to measure $\dot{A}_t$, TFP as reported in EUKLEMS.

The parameters α ,γ, and η vary very little over the sample from 1995 – 2015, thus we used the country averages, except for η, which we allowed to vary albeit the variations are small. Table (1) reports the averages of these time series parameters by country. We reported three different estimates for η, which are very similar.

The relationship between global research efforts and TFP in the financial sector

TFP, whether for the economy or the sectors, is endogenous. The theory TFP in the financial sector A_{F_t} depends on global research efforts is key in this model. Given that we do not have data for the number of researchers in finance across countries and the amount of human capital, we computed global research effort by country $H_{A_{it}} = h_{it}^{\theta} L_{Ait}$ for the year 1995 and the year 2014 for each country. We followed the same calculation that we used for γ earlier (except here we do not sum over the countries). Then we computed $H_{A_{F_t}} = \varepsilon H_{A_t}$;$0 \leq \varepsilon \leq 1$ to measure global research efforts in the financial sectors. We tried different values for ε; we used a number of values between zero and 1. We then computed the growth rate $\dot{H}_{AF_t}$ over the period 1995 to 2014 for each country. We found the fit to be best when we assume the financial sector's $\dot{H}_{AF_t}$ is 30 percent of the economy-wide $\dot{H}_{At}$. We plot the average TFP growth rate in the financial sectors for each country against the average growth rate of global research efforts in finance for ε = 0.30 in figure (1).

Figure (1)



The 45° line indicates that there is a reasonably good fit, except for Germany, Austria, and Finland. We will shed more light on these large variations later.

The transitional dynamic

First, we examine the economy-wide transitional dynamic using equation (32). Second, we examine the relationship between excess knowledge in the financial sectors and the economy-wide productivity growth.

We plot the *average* productivity growth rate for each country, $\dot{y}_{it}$, over the time series sample against the following averages of the transitional dynamic equations (31) and (32):

$$\frac{\alpha}{1-\alpha}(\dot{K}_{it} - \dot{Y}_{it});\ \dot{h}_{it};\ \dot{\ell}_{it};\text{ and }\frac{\sigma}{1-\alpha}(\dot{A}_{it} - \gamma\, n)\text{ and }\frac{\sigma}{\eta(1-\alpha)}(\dot{A}_{F_{it}} - \gamma n)$$

Prescott (1997) stated that neither factor inputs, nor savings differential or intangible capital differential explain international productivity growth differentials. We define differentials in this paper by the the U.S. magnitudes less country i magnitudes.

First, for the capital-output ratio, we test the correlation between the deviations of the average US $\frac{\alpha}{1-\alpha}\left(\dot{K_t} - \dot{Y_t}\right)$ from the average of $\frac{\alpha}{1-\alpha}\left(\dot{K_t} - \dot{Y_t}\right)$ for country $i = 1\ to\ 10$, against the average growth rate of real values added per hour-worked differentials between the U.S. and every other country, i.e. $\dot{y}$ for the U.S. less $\dot{y}$ for country $i = 1\ to\ 10$. We plot 10 values. Figure (2) plots the data along the 45° line. The correlation is very weak. This is consistent with Prescott's (2004) assertion that capital-output ratio or saving differentials do not explain productivity growth differentials.

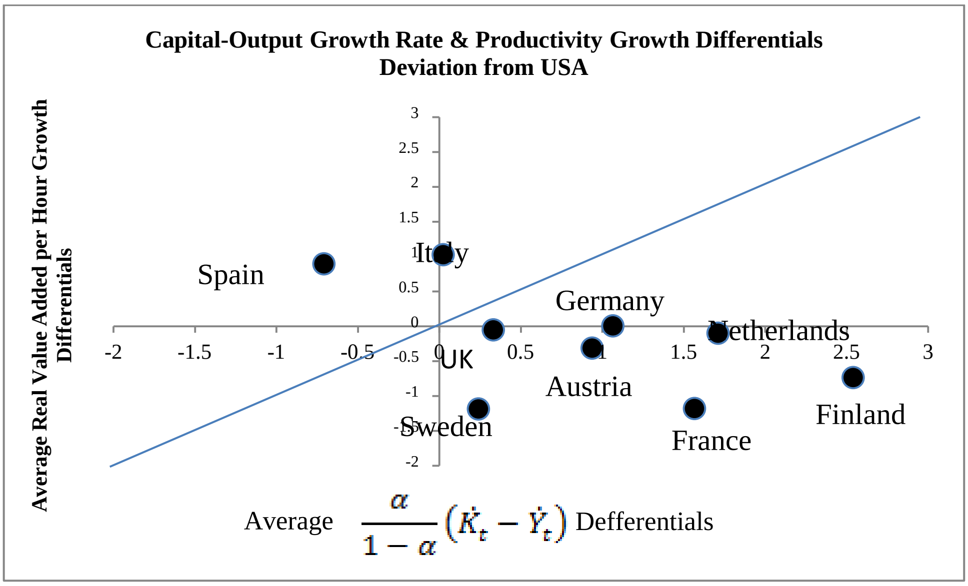
Similarly, figure (3) plots the deviation of the average U.S. human capital growth $\dot{h_t}$ from the average of every other country against the average growth rate of real value added per hour-worked. The correlation is relatively tighter for a subgroup of countries. Human capital growth differentials of Italy, Spain, France and Sweden are uncorrelated with productivity growth differentials.

Figure (4) plots the deviation of the average U.S. labor growth $\dot{\ell}_t$ from the average labor growth of every other country against the average hours-worked growth rate differentials. Labor differentials explain much more of productivity growth differentials than the capital-output ratio and human capital growth rates differentials.

Figure (5) plots excess knowledge differentials and productivity growth. This plot is significantly different from all other variables. Excess knowledge differentials; explain 80 percent of the productivity growth differentials. This lends support to the model and the underlying argument that excess knowledge is driven by TFP, which is a function of global research efforts.

Essentially, productivity growth differentials in advanced countries boil down, mostly, to technological gaps.

Figure (2)



Belgium has no capital stock data

Figure (3)

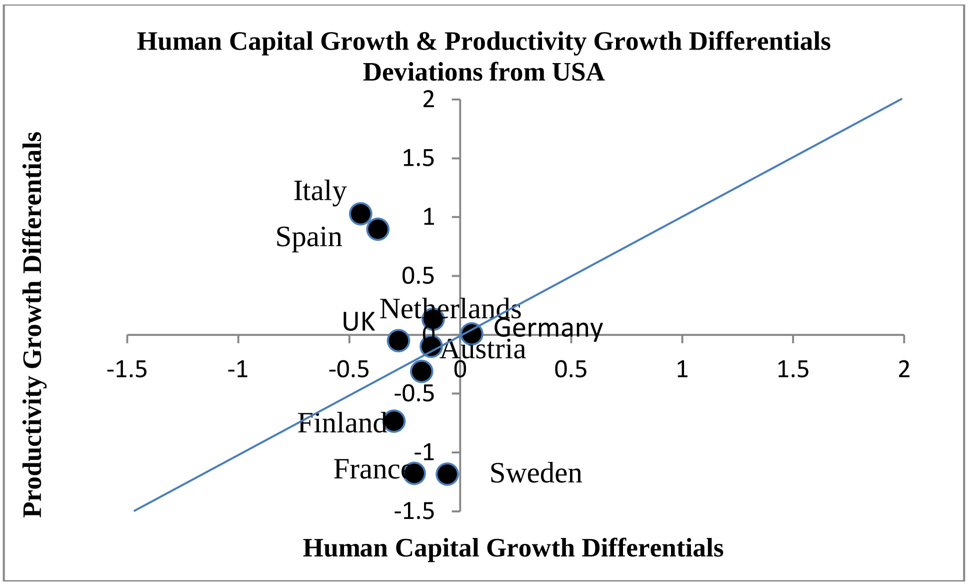


Figure (4)

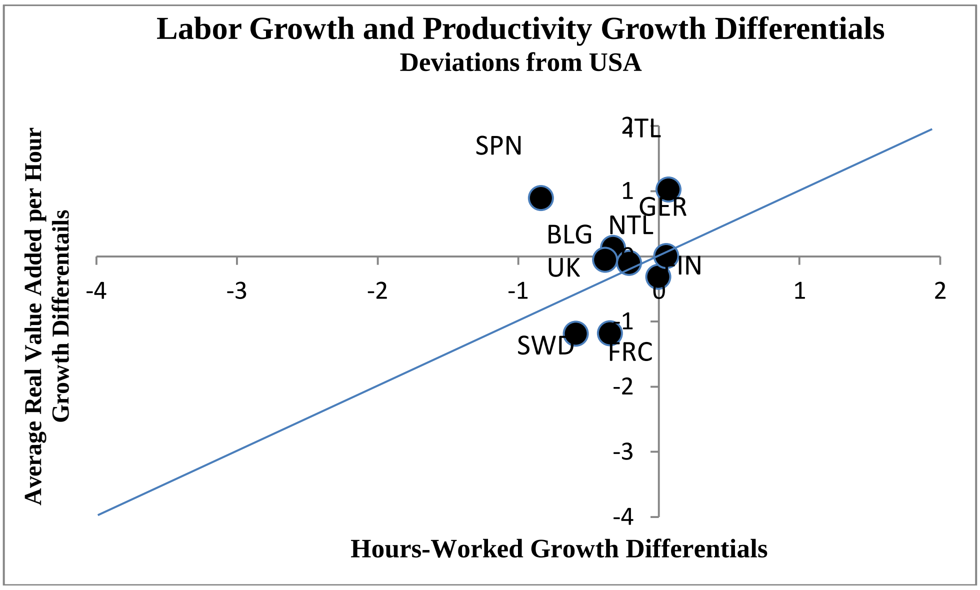
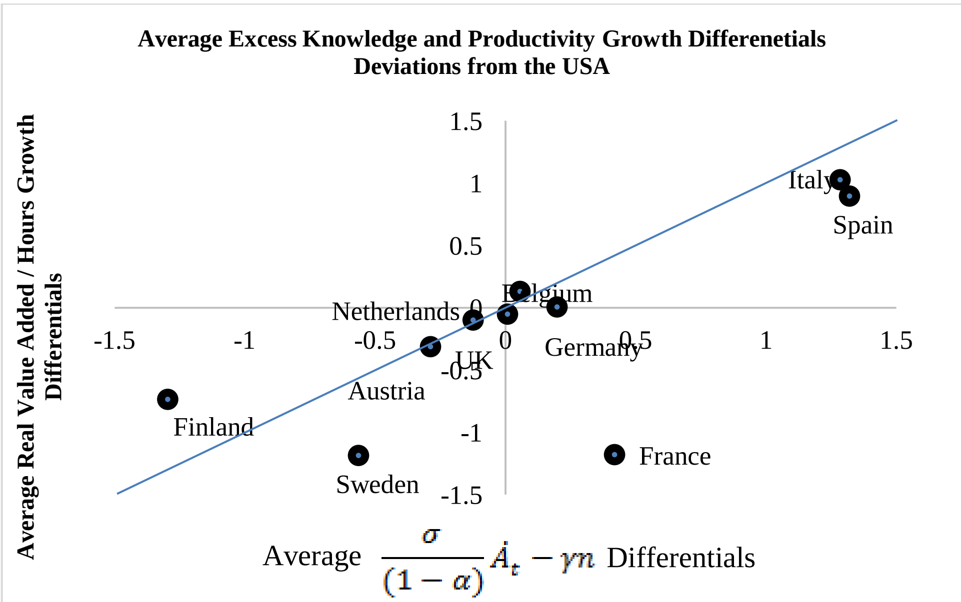


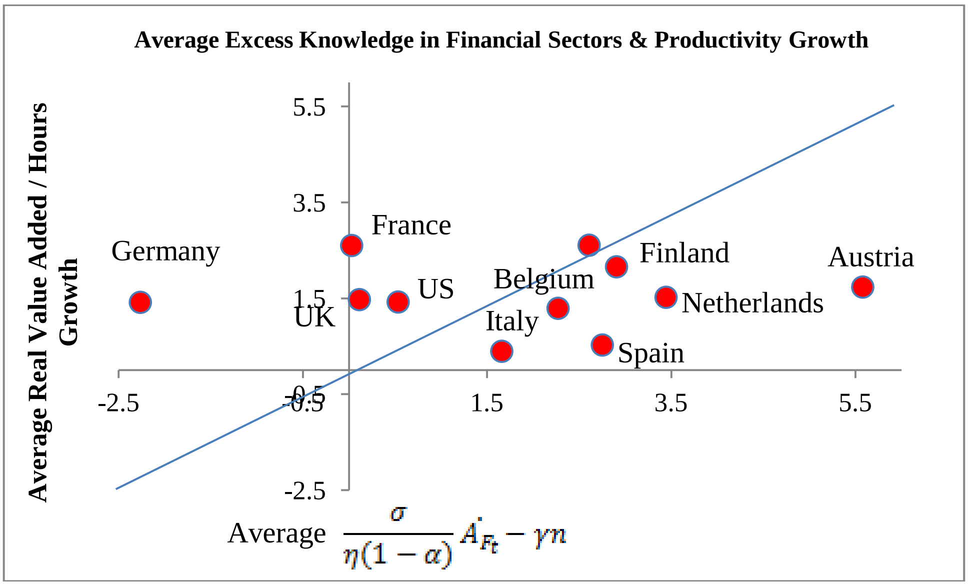
Figure (5)



Does excess knowledge in the financial sector explain productivity growth?

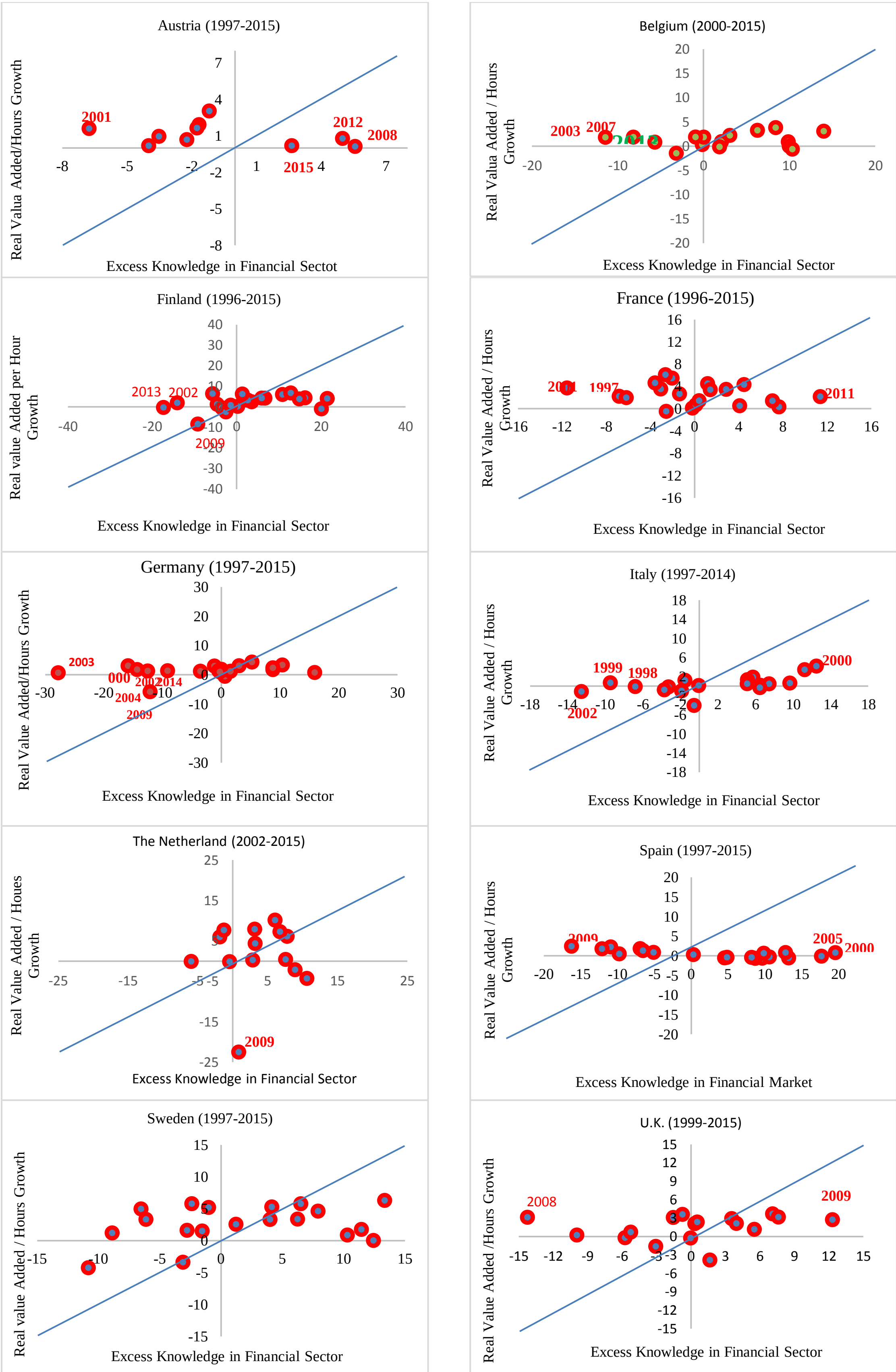
The last test is for average excess knowledge in the financial sectors and the average productivity growth for all 11 countries. We do not use *differentials*, but using differentials do not alter the results. The correlation is not as strong as for the economy-wide excess knowledge. However, financial sectors seem to explain relatively some of the economy-wide productivity growth. The variance is large, which is driven, mostly, by Germany and Austria.

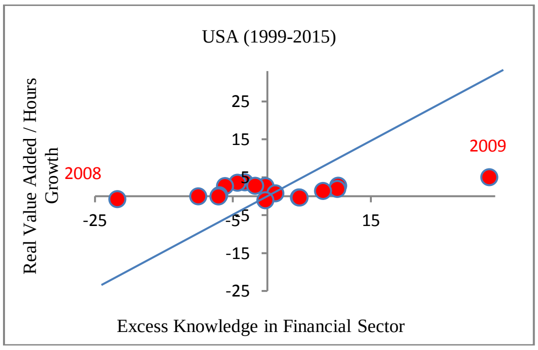
Figure (6)



We plot country, , time series data to shed more light on the correlation between excess knowledge in the financial sector and productivity growth. Figure (7) shows that some countries have a relatively stronger correlation between productivity growth and excess knowledge in the financial sector while others do not show any. France and Finland have stronger correlation than in Austria, Belgium, Germany and Italy. Spain is particularly weak. The U.S. and the U.K. variance is highly affected by the recessions, especially in 2008 - 2009 recession that followed the global financial crisis.

Figure (7) Excess Knowledge in the Financial Sectors & Productivity Growth





2. Conclusions

We provide an alternative way to testing the finance-led-growth hypothesis. We modify Jones (2002) simple semi-endogenous growth model to allow for a sectoral effect on productivity growth and use EUKLEMS data set to test the hypothesis in ten European advanced economies and the United States for the period 1995 to 2015.

The model has a transitional dynamic path and a steady state path. The steady state is anchored by population growth (scale). The transitional dynamic is determined by factor input growth rates and *excess knowledge*. Excess knowledge is the gap between TFP growth and the steady state growth. As investments in education, skills, and the proportion of the labor force engaged in scientific research increase, so do global research efforts. As a result TFP growth increases and the economy settles at a higher growth path. The economy's transitional dynamic growth path declines when global research efforts decline because of the lack of investments in research, which reduce human capital and the number of researchers and research output. In the modified version of the model, excess knowledge in the financial sector is the gap between TFP growth in the sector and steady state growth. As sectoral TFP grows faster than population, productivity growth increases.

We report positive results.

First, we show that TFP is endogenous and driven by *global research efforts*. Second is that the model explains 80 percent of the productivity growth differentials, i.e., the difference between the U.S. productivity growth and any of the ten European countries in the sample. Further, most of the explanation comes from what we called *excess knowledge* differentials. Finally, we find a relatively positive relationship between excess knowledge in the financial sector and the economy-wide productivity growth. This relationship appears to be affected by financial crisis, e.g., the Asian financial crisis and the Global Financial Crisis, and the subsequent recessions.

Table (1)

				η		
Country	σ	α	γ	Average $\eta = \frac{\ln(A_{Ft})}{\ln(A_{t_t})}$	Time Series regression	Cross Section regression
Austria	1	0.41	0.40	0.996	0.960	0.966
Belgium	1	0.37	0.28	0.998	0.998	1.004
Finland	1	0.41	0.81	0.995	0.995	1.001
France	1	0.38	0.12	0.996	0.996	1.025
Germany	1	0.37	0.35	0.984	1.023	1.029
Italy	1	0.47	-0.20	0.977	0.997	0.983
Netherlands	1	0.39	0.23	0.976	1.000	0.984
Spain	1	0.37	-0.28	0.959	0.959	0.965
Sweden	1	0.46	0.43	1.000	1.006	1.012
U.K.	1	0.38	0.33	0.992	0.985	0.991
U.S.	1	0.38	0.30	0.998	0.997	1.004

We conducted a sensitivity analysis for σ using values equal to $1-\alpha$ up to one and we found that a value of one gives the best fit. The regression is $lnA_{Ft} = \eta_0 + \eta ln\mathrm{A}_t + \epsilon_t$. In the cross – section regression the parameter η varies across countries, cross-section weights, and heteroscedastic stnadrd errors. The constant term is estimated to be zero in all regressions. Commonly used tests indicate the rejection of "no cointegration" null hypothesis.

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Data Appendix

- The data are from EUKLEMS (2017). The data set include all European countries and the United States. However, we only use the original EUKLEMS EU10 and the United States because the required data for the other countries are incomplete.
- We measure productivity y_{it} by real value added per hours worked. We deflate the value added VA (Gross value added at current basic prices- in millions of national currency) by the price VA_P (Gross value added, price indices, 2010 = 100) then divide by hours worked H_EMP (Total hours worked by persons engaged in thousands). EU Stat defines gross Value Added (VA) as output value at basic prices *less* intermediate consumption valued at purchasers' prices. VA is calculated before consumption of fixed capital.
- The aggregate TFP is Market Economy data. The Market Economy measure excludes lines L, O, P, Q, T, and U, which are the sectors real estate activity; Public administration and defense; compulsory social security; Education, Health and Social Work; and Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use.
- The data for the market value added output, prices, and hours are from 1995 to 2015. The *level* of market TFP and TFP for the financial sector varies in sample. For Austria (1996-2015); Belgium (1999-2015); Finland (1996-2015); France (1995-2015); Germany (1996-2015); Italy (1996-2015); The Netherlands (2001-2015); Spain (1996-2015); Sweden (1996-2015), U.K. (1998-2015); and the U.S. (1999-2015).
- The share of labor / capital and the human capital index are from the Penn World Table 9.0.
- Population is measured by the Labor Force as in Jones (2002), from OECD data.
- The data for the number of researchers are from the World Bank.

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[i] Early writings include Schumpeter (1911), who argued that efficient financial markets, via the credit channel, help innovative entrepreneurs to embark on innovative business activities, and that how the economy grows. Similarly, Gurley and Shaw (1955), Goldsmith (1969) and Hicks (1969) argued that a well-developed financial system is important to stimulating economic growth. McKinnon (1973) and Shaw (1973) have contributed significantly to this literature with slightly different models. They provided a counter-argument to Keynes's (1939) financial repression argument and suggested that growth requires financial liberalization, where the interest rate is market-determined.

In the 1990s, endogenous growth models due to Romer (1986) treated finance as an external effect on aggregate investment efficiency, which offsets the diminishing marginal product of capital, and sustain growth. Bencivenga and Smith (1991), Roubini and Sala-i-Martin (1992), King and Levine (1993), and Mattesini (1996) are among a number of papers, which use endogenous growth models, though differ in many important aspects. For example, in Roubini and Sala-i-Martin (1992), just like Keynes (1939), financial repression is not ruled out. King and Levine (1993) have a Schumpeterian model of technical progress similar to Romer (1990) and Grossman and Helpman (1991), with a cost-reducing inventions applying to an intermediate product. Financial market affects technical progress by increasing the probability of having successful innovative projects, hence growth.

That said, there were a number of counter-arguments. Robinson (1952) suggests that causality does not run from financial development to economic growth, but rather the other way, economic growth leads to a higher demand for financial services. Lucas (1988) argues that financial services do not cause growth.

Modigliani and Miller (1958) is a model, where essentially the real economy is independent of the financial system. Fama (1980) shows that in a competitive banking sector with equal access to capital markets, a single bank lending decision will have no effect on real economy. Keynes (1936) warned against the destabilizing effects of stocks markets on the real economy. See also Singh (1977) for a similar argument about the adverse real effects of stock markets on developing countries. Minsky (1975) emphasized that financial crisis – increasing market risks – which result from instability in financial markets and can have an adverse effect on the real economy. Stiglitz (2000) also warned that financial liberalization is associated with financial crisis and lower growth.

[ii] The capital accumulation channel is essentially a savings-investments-growth channel. A more efficient financial system mobilizes savings and channels them through the sectors of the economy in the form of productive investments, e.g., Wicksell (1935), Shaw (1955), and Tobin and Brainard (1963). Furthermore, efficient financial systems allow investors to diversify portfolios and hedge against risks (e.g., Diamond and Dybvig, 1983 and Bencivenga and Smith, 1991). Financial intermediaries manage and invest funds at a lower cost (e.g., Gurley and Shaw, 1960). Diamond (1984) also shows that that monitoring costs is reduced through efficient financial arrangements.

[iii] Cecchetti and Kharroubi (2012), Boyer (2000), and Rousseau, P/ L/ and P Wachtel, (2002) for exemple.

[iv] For example, see the contributions of Modigliani and Miller; (1958); Arrow (1965); Black and Scholes (1972); Merton, Scholes, and Gladstein (1978); Fama (1980) on the Efficient Market Hypothesis; Engle's several contributions e.g., ARCH, GARCH etc models (e.g., 1982); Lucas (e.g. 1978) on asset prices; and the ideas and research behind the innovations and the various financial products.

[v] The fraction of output that is spent is $1-S_{Kt}$.

[vi] Razzak and Laabas (2016) modify (8) by introducing the quality of human capital such that the equation becomes $h_t = e^{\varphi \xi l h_t}$, where the additional parameter ξ is relative cognitive skills for country j and the country with the highest level of skills.

[vii] Jones (2002) articulates that he made the model more complicated by assuming ideas are not instantaneously available for use by other countries, but rather functions of some economic factors. He assumed that ideas must be learned before they can be used in production. He found this complication did not alter the final results.