The Role of Capital Market Efficiency in Long-term Growth: A Quantitative Exploration

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Abstract
This paper provides a computable neoclassical model with financial intermediation to examine the hypothesis that financial development (i.e., bank efficiency improvement) positively influences growth through mitigating the capital market frictions. The calibrations and counterfactual experiments show that an improvement in bank efficiency enhances long-term welfare and raises output and capital as well as their growth rates in general. However, the growth effect on output depends on the substitutability between firm-owned assets and loans. Therefore, this model quantitatively supports the argument that efficient financial intermediation can (but does not always) exert a positive impact on long-term economic growth.

Keywords: Neoclassical, Growth, Efficiency of financial intermediation, Euler equation wedge
JEL: E13, E44, O11, O16, O53

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1. Introduction

The view that efficient financial intermediation is crucial to economic development and positively influences growth is well known but remains disputed. Some evidence from cross-country studies supports the view that efficient financial intermediation is crucial to economic development and positively influences growth (e.g., King and Levine 1993a and 1993b; Beck, Levine and Loayza 2000; Levine, Loayza and Beck 2000). Other evidence suggests a contrary view that this role is not always significant – as summarized in Deidda (2005). In this paper, the focal point is to set up a computable general equilibrium model to quantitatively explore the hypothesis that the technological improvement in banking (which intermediates funds between depositors and borrowers in terms of intermediation costs) enhances growth. In particular, I provide calibration and counterfactual experiments (in view of steady state and transition dynamics) under the context of Taiwan\(^1\) from 1961 to 2005 and quantitatively explore the consequence of financial development on growth.

Following Cole and Ohanian (1999 & 2002), Chari, Kehoe and McGrattan (2002 & 2007) and Mulligan (2005), I first quantify the evolution of capital market frictions by using the Euler equation wedge. The preliminarily results show that the improvement in the capital market conditions (i.e., reflected by the declining Euler equation wedge) can be quantitatively important in explaining why some economies are catching up with the U.S.\(^2\) Since banking is an important source of finance to firms, I quantitatively explore the issue of the impact of bank efficiency on long-term growth. This particular interpretation for the Euler equation wedge coincide with the well known viewpoint in the development literature that financial development positively enhances growth (e.g., Schumpeter, 2000).

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\(^1\) Taiwan is an exceptional case study in growth as the rate at which it has caught up with the US is amazing. Since 1951, it has been one of the fastest growing economies among the newly-industrializing countries. In 1951, the Taiwanese real GDP per capita was 8% of the U.S. level (equivalent to India’s relative income to the U.S. in 2002), and the corresponding figure was 54.24% in 2004 (equivalent to the average of Spain’s and Portugal’s relative income to the U.S. in 2004 which was equal to 54.06%). In other words, Taiwan has been rapidly catching up with the U.S. since WWII. (Source: Penn World Table 6.2)

\(^2\) The Euler equation wedge is the gap between the right- and left-hand sides of the Euler equation when plugging the time series data for an economy into a Ramsey-Cass-Koopmans type of deterministic, discrete-time growth model. Figure 1 shows the Euler equation wedges for Taiwan and the U.S. As can be seen, the Taiwanese pattern is significantly different from the roughly constant U.S. pattern. The wedges are relatively volatile and decline dramatically. This declining pattern also holds for South Korea.

Previous theoretical models regarding finance and growth$^3$ have mainly focused on the provision of risk sharing and the more efficient allocation of capital to more productive and illiquid assets (e.g., Bencivenga and Smith, 1991 & 1998; Greenwood and Smith 1997; Greenwood and Jovanovic, 1990). More recent work has focused on its role in boosting R&D (e.g., Morales 2003; Aghion, Howitt and Mayer-Foulkes 2005). These theoretical papers support the view that financial development has a positive impact on growth in the long run. Finally, Deidda (2005) justifies the existence of financial intermediaries and finds that the growth effect is ambiguous when an economy transitions from financial autarky to financial intermediation.

In this paper, I quantitatively study this important question regarding finance and growth with calibration and counterfactual experiments by controlling certain specific economic conditions, i.e., parameters. The model used is different from the previous models, in that it isolates the externality of financial intermediation$^4$ and only focuses on the simple role of the bank in channeling saving to firms. The model shows that the improvement in efficiency of this particular function of the bank contributes to growth in the context of Taiwan.

The model in the paper is based on a version of the neoclassical growth model that allows firms to own assets. In addition to standard consumer preferences and firm production technologies, the model contains three special features. First, financial intermediaries (i.e., bankers) intermediate funds between agents and firms. Second, banks “produce” loans (to firms) using labor and deposits (collected from the family) as inputs. Finally, firms need intra-temporal borrowing (loans) and firm-owned assets to produce capital, which firms allocate into production. Firms need loans for their operating cash flow. In this model, financial intermediaries are narrowed down to banks so that

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$^3$ An extensive literature review on finance and growth can be found in Pagano (1993), Levine (1997), and Demirguc-Kunt and Levine (2008).

$^4$ I treat the increase in total factor productivity as exogenous.
they accept deposits and make loans. The capital market efficiency is abstracted for simplification. I refer to bank efficiency as capital market efficiency and it is exogenously determined. The more efficient banks are, the less resources are lost when funneling savings to firms.

Under the above settings, I first explore whether an improvement in bank efficiency explains the huge decline in the Euler equation wedge in Taiwan. My model with financial intermediation reduces the Euler equation wedge found under the vanilla model during the early development phase. Before 1980, my model explains 53% of the wedge on average.

Second, I use the same model to investigate whether it is true in a quantitative sense (as the empirical findings suggest) that bank efficiency is relevant to growth. The general equilibrium model in this paper demonstrates the property that higher bank efficiency corresponds to greater economic output in the steady state within some range for parameter $\sigma$ (the elasticity of substitution between loans and firm-owned assets). For the Taiwanese case, the model shows that its output level today is 3.20% higher as a result of bank efficiency improvements. The impact would have been smaller if firm-owned assets and loans had been more substitutable. The result here concludes that financial development tends to exert a positive effect on growth, but this is not always the case.

Third, the quantitative results reveal the transition dynamics for the Taiwanese economy from a low to a high steady state under the low and high efficiency of financial intermediaries (given the productivity level and the reserve requirement ratio at the steady state). The transition dynamics indicates that the improvement in bank efficiency has a positive effect on output, capital, and their

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5 The setup of the model is motivated by three figures. I focus on the comparison between Taiwan and the U.S. because the focal point is why Taiwan could rapidly catch up with the U.S. after WWII. Figures 2 and 3 show two bank efficiency indicators: the interest rate spread between lending and deposit rates (SPREAD) and the ratio of real loans per employee in the financial institutions (LOAN PER EMP) for Taiwan and the U.S. I describe these two indicators in Appendix 3. As can be seen, these two bank efficiency indicators imply that the capital market conditions in Taiwan experienced a dramatic improvement in contrast to those in the U.S. Finally, Figure 4 shows the Euler equation wedge (WEDGE) and SPREAD in Taiwan. As can be seen, both series exhibit a declining trend and are highly correlated (the correlation coefficient is 0.86). These empirical findings motivate me to link my explanation for the huge decline in the Euler equation wedge to the development literature which emphasizes the importance of financial development in growth. Therefore, I set up a dynamic general equilibrium model to quantitatively assess the hypothesis that financial development (i.e., bank efficiency improvement) causes growth.

6 This reduced-form modeling of bank efficiency is similar to Pagano (1993). The leakage of resources reflects the X-efficiency of the financial intermediaries.
growth rates and enhances welfare. However, I find that the effect on the saving rate is ambiguous: households choose to save more (higher household savings) and firms choose to rely more on intermediated funds (lower firm savings) as bank efficiency improves. Consequently, the two opposite forces lead to an ambiguous effect on the national saving rate. These results are similar to the empirical findings of Beck, Levine and Loayza (2000) in the development literature. In addition, the model also shows the property that firms’ financing choices switch from the un-intermediated to the intermediated financing of investment during growth in the long run. Such an observation coincides with the viewpoint of Gurley and Shaw (1955) regarding finance and growth. Therefore, the findings quantitatively support the view that the efficiency of financial intermediation has a positive impact on economic growth in the long run through a mechanism which efficiently intermediates resources but not necessarily through adjustments in saving rates.

The remainder of this paper is organized as follows: First, I set up a neoclassical model with financial intermediation to quantitatively assess the hypothesis that financial development causes growth. Second, I implement the model with calibration and simulation. The quantitative exploration addresses four issues: (1) How does the model with financial intermediation (bank efficiency improvement) explain the evolution of capital market efficiency, which is characterized by the declining Euler equation wedge? (2) Is it true in a quantitative sense (as the empirical findings suggest) that bank efficiency is relevant to growth? (3) What is the force at work which enables the bank efficiency improvement to raise output? Is it by efficiently reallocating resources or by altering saving rates? (4) Can the bank efficiency improvement enhance welfare? Finally, I offer concluding remarks and point out various possible areas for future research.

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7 The impact on output and capital growth is negative at the very early development phase. In my simulation, the negative impact only shows up for the growth from 1961 to 1962.
2. The Model

The model is based upon a version of the standard neoclassical growth model that allows firms to own assets. In addition to the standard setup, I introduce a banking sector, which intermediates funds between agents and firms, and provides firms with intra-period financing for operating cash flow. Firms combine the intra-period financing and self-owned assets and transform them (with CES technology) into capital for production. Furthermore, banks own the technology to transform savings, i.e., deposits, into loans. Cobb-Douglas technology is assumed.

2.1. The Economy

The economy of the model is composed of a representative family, banks and producers in a perfect foresight environment. Individuals may face shocks but the shocks only last for one period.

2.1.1 The Representative Family

I adopt a special form of the CES utility function for the representative family in this economy. Agents value leisure and there is one unit of labor available in each period. In addition, they are infinitely lived. Hence, preferences are as follows:

\[
Max \left\{ u(C) = \sum_{t=0}^{\infty} \beta^t \left\{ \log(C_t) + \phi \log(1 - \hat{H}_t) \right\} \right\}
\]

where \( C \) is the family’s consumption, and \( \hat{H} \) is the total labor the family provides. The discount factor is represented by \( \beta \) and \( \phi \) is the coefficient for leisure in the agent’s utility.

Finally, the population grows deterministically at the rate \( \nu \), and thus population \( n_t \) at time \( t \) can be expressed as follows: \( n_t = (1 + \nu)^t \)

2.1.2 Production Sector

Firms in this economy adopt a Cobb-Douglas production technology with labor-augmenting technological change. Furthermore, the firms use a CES technology to combine self-owned assets
with loans to create capital \((K)\). Firms need loans for operating cash flow and firm-owned assets are fixed assets.

A single firm in this economy uses the labor-augmented Cobb-Douglas production function to produce goods. Based on the constant returns to scale property of the Cobb-Douglas production function, the production technology for the whole sector can be expressed as equation (1) below:

\[
Y_t = K_t^{\theta} (H_t^f)^{1-\theta}
\]

In this economy, firms combine self-owned assets with bank loans to produce capital; hereafter, I term this process “fostering capital”. Based on the constant returns to scale property of the CES production function, the technology for productive capital for the whole sector can be expressed as equation (2) as follows:

\[
K = \Psi \{(1 - \theta) (H^f)^{-\rho} + \theta (L)^{-\rho}\}^{\frac{-1}{\rho}}
\]

\text{In equation (1), } Y \text{ is the aggregate output, } K \text{ is the aggregate capital input providing capital services, and } H^f \text{ is the aggregate labor input in the production. In equation (2), } K' \text{ is the aggregate firm-owned assets, and } L \text{ is aggregated loans. In addition, } \theta \text{ is the capital share and } g \text{ is the growth rate of the labor-augmenting technology, } \Psi \text{ is an efficiency parameter (a scaling factor), } \alpha \text{ is the income share parameter for firm-owned assets, which approximates the firms’ financial structure, and } \rho \text{ is a substitution parameter that governs the elasticity of substitution between loans and firm-owned assets in fostering capital. The elasticity of substitution } (\sigma) \text{ is the inverse of } (1 + \rho). \text{ That is,}

\[
\sigma = \frac{1}{(1 + \rho)}
\]

\subsection*{2.1.3 The Financial Intermediation Sector}

The main function of financial intermediaries, also called banks, is intermediating funds between lenders (households) and borrowers (firms). Conceptually\(^9\), I follow Sealey and Lindley (1977),

\(^8\) I assume the firm-owned asset \((K')\) is nontradable goods whereas output \((Y)\) consists of the only tradable goods in this economy. This assumption allows the model to be simplified to one good economy. A similar setting (i.e., nontradable output) can be found in Kiyotaki and Moore (1997).

\(^9\) In Sealey and Lindley (1977), and Cole and Ohanian (2000), the loan is the minimum of either ‘loans plus securities’ and ‘deposit net of reserves’ or ‘uninstalled physical capital held by households’ and ‘intermediation capital’. Goodfriend and McCallum (2007) allow
Clark (1984), Cole and Ohanian (2000), and Goodfriend and McCallum (2007) and adopt Cobb-Douglas technology to characterize the banks’ production technology. I also assume that this sector is perfectly competitive.

The production technology combines bank labor and deposits to derive loans. For an individual bank, loans can be created by using a Cobb-Douglas technology. By the constant returns to scale property of the Cobb-Douglas production function, the production technology for the whole sector can be expressed as equation (3) below:

$$\hat{L} = e_i \left( (1 - \gamma)D_i \right)^\eta \left( H^b_i \right)^{(1-\eta)}$$

In equation (3), $\hat{L}$ is aggregate loans, $D$ is aggregate deposits, and $\hat{H}^b$ is the aggregate labor input in banking. $\gamma$ is the required reserves ratio. In addition, $\eta$ approximates the weights on deposits. “$e_i$” is the exogenous efficiency parameter for banks, and characterizes how efficient banks are in generating loans out of their inputs: deposits and labor. With this setting, bank efficiency and loans per employee are positively related. This completes the specification of the model. The detailed computations for the equilibrium are given in Appendix 1.

3. Calibration

In this section, I show the parameterization of the model. The results of the parameterization are summarized in Table 1. Then, I compare the steady state of the model with the data and show that the model fits the data well. The results of the comparison are summarized in Table 2.

3.1 Parameterization

Before I pin down the parameters (e.g., $\Psi, \rho, \alpha; \eta; \Phi, \beta$), I set the values of the other parameters (e.g., $\theta, \upsilon, \delta, g$) either based on convention or on the average for the data from 2001 to 2005 (also

banks to produce loans using Cobb-Douglas technology to combine labor and collateral. Finally, the Cobb-Douglas assumption is supported by Clark (1984). In his paper, he concludes by saying that “the assumption of a Cobb-Douglas production function does not appear to be inappropriate” (p.67) as a description of the production process of financial intermediaries.
referred to as the steady state from now on). I choose the average of this period as the steady state because I observe that the capital to output ratio in Taiwan during this period fluctuates within the range from 1.86 to 1.97 and its consumption to output ratio fluctuates within the range from 0.64 to 0.67. \( \Psi, \rho \) and \( \alpha \) are the parameters for the firm’s CES function for capital formation, whereas \( \eta \) is that for the bank’s Cobb-Douglas function for converting deposits and bank workers into loans. \( \phi \) and \( \beta \) are the parameters for the household’s utility function.

The capital share (\( \theta \)) is chosen to be half of the labor share (\( \theta = 1/3 \)) following the convention. Based on the Taiwanese statistics of the steady state, I set the population growth rate (\( \nu = 1.1\% \)) and the depreciation rate (\( \delta = 6.5\% \)), and I assume that the balanced growth rate of the economy equals the average world growth rate (\( g = 2\% \)). In addition, I assume that the productivity shocks (\( Z \)) from 2006 onward are the same as the average of the \( Z \) from 2001 to 2005.

To pin down the discount factor (\( \beta \)), I set the deposit rate at the steady state as 2.54%. In addition, I assume that the economy is on a balanced growth path after it reaches its steady state. Therefore, from equation (A1.10), \( \beta = \frac{(1 + g)}{1 + r_{SS}^D} \). To pin down the coefficient (\( \phi \)) for leisure in the utility function, I assume that the consumption- and output-to-labor ratios at steady states (SS) are equal to the average of those from 2001 to 2005. Thus from equation (A1.9),

\[
\phi = (1 - \tilde{H}_{SS}^f - \tilde{H}_{SS}^b) \frac{(1 - \theta)\tilde{y}_Y / \tilde{y}_{f}'}{C_{SS}}
\]

To pin down the scalar for the labor augmenting production technology (\( x_0 \)), I assume that the productivity shock (\( Z \)) equals one in the initial year. Therefore, \( Z_{initial} = \frac{\tilde{Y}_{initial}}{\tilde{K}_{initial}^\theta (\tilde{H}_{initial}^f x_0)^{1-\theta}} = 1 \).

To pin down \( \alpha \) and \( \Psi \) in equation (A1.2), I plug in the value of the steady state in Taiwan for the capital-output ratio \( (K/Y=1.9135) \) and the loan-to-output ratio \( (L/Y=1.3174) \). To pin down the substitution parameter (\( \rho \)) for the firms’ CES technology in “fostering capital,” I use the relationship
between the lending rate, the capital-output ratio and the loan-to-capital ratio in 1961 relative to the steady state values. From equation (A1.4) for 1961 and the steady state, I obtain the following equation:

\[ r_{SS}^L = \frac{Y_{SS}}{K_{SS}} \left( \frac{K_{SS}}{L_{SS}} \right)^{1+\rho} \]

The value for \( \rho \) then depends on the lending rate in 1961 and on the steady state. I choose an interest rate spread between the lending and deposit rate at the steady state as 2.22%, given the fact that the average spread is 2.22% from 2001 to 2005. Consequently, the lending rate in the steady state equals 4.76%. Moreover, I set the lending rate in 1961 equal to 15.97%\(^{10}\). The calibrated negative \( \rho \) (\( \rho = -0.5976 \)) implies that the firm’s self-owned assets and bank loans are substitutes\(^{11}\).

To pin down the parameters for the technology for the bank (i.e., \( \eta \)) as in equation (A1.3), I assume the averages of the following variables from 2001 to 2005 are the steady state values: the loan-to-bank employee ratio, the loan-to-output ratio, and wages. Table 1 shows the results of the calibration. Notice that the discount factor is 0.995, which is above the standard assumption (0.95). This is because agents hold bank deposits and earn returns on their deposits rather than returns on capital in this model. Therefore, in the model, agents must be extremely patient to save and earn deposit rates.

### 3.2 Data versus the steady states of the model

To show how well the model fits the data, I compare “SS in Data” with “SS in Model” in Table 2. “SS in Data” in the table are the averages of the data from 2001 to 2005 and they represent the

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\(^{10}\) The lending and borrowing activity is intra-temporal in the model and the rates are volatile in the 1960s. Therefore, I adopt the rate at the beginning of the year to calibrate \( \rho \). The datasets from the Central Bank of China, the Global Financial Database and Ho, Shia, Chang, Wang and Hu (2005) show that the discount rate and the prime rate are both 18% (at least until June 30, 1961), and the unsecured loans rate is 20.88%. Therefore, the interest rate that characterizes the economy should be higher than the discount rate – the interest rate charged for inter-bank loans. Since the interest rates for secured loans are the same as the discount rate, and one should expect that firms’ loans were charged higher lending rates than the inter-bank loans, I use 20.88% as the lending rate at the beginning of 1961. This is not an extreme assumption since the black market rate was about 30% to 45% for collateral loans by then, and black market loans were another major source of funding in addition to bank loans (only about 49% of loans were from financial institutions in 1964. The number increased to 72% by 1973). Since this is a nominal interest rate, it must be deflated to obtain the real interest rate. I use the GDP deflator to deflate the interest rate, which results in 15.97% for real loan rates in 1961.

\(^{11}\) This parameter is critical in determining the impact of financial development on growth in the model. Therefore, I will perform sensitivity analysis on this parameter in Section 4.3.
realized steady state in Taiwan. On the other hand, “SS in Model” represents the steady state of the model. As can be seen, the capital market is more active and efficient in reality than is suggested by the model. For example, the numbers for all the banking-related variables, i.e., the L/Y (loan-to-output ratio), D/Y (deposit-to-output ratio), and H°/H°+H° (the percentage of workers in the financial sector) are higher under “SS in Data” than under “SS in Model”. In other words, the Taiwanese banking sector uses more inputs (labor and deposits) and generates more output (loans) than the model predicts. In addition, financial intermediation is more efficient in reality: “SS in Data” has a lower lending rate (\( r^L \)) and a smaller Spread (\( r^L - r^D \)) than “SS in Model”. Consequently, “SS in Data” ends up having a slightly higher capital-to-output ratio than the model suggests. All of the above may be due to the fact that the model omits the other role of financial intermediation, (e.g. risk management and other profit generating services) and thus underestimates the capital market efficiency.

The deposit rate (\( r^D \)) is exactly the same for both cases because it is the number I use to calibrate the discount factor (\( \beta \)). Moreover, the consumption-to-output ratio (C/Y) of “SS in Data” is larger than that of “SS in Model”. Again, the difference may be due to the fact that households in fact face less intermediation friction and are thus can afford to consume a bit more in reality. Overall, the model fits the data well and I show how good this model is in accounting for the changes in capital market efficiency (i.e., the Euler equation wedge) and growth.

4. Macroeconomic results

I discuss the following four questions from the neoclassical perspective in this section. First, by how much can the model with financial intermediation explain the evolution in the capital market, which is characterized by the declining Euler equation wedge? Second, I discuss two issues based on the steady state analysis: By how much is the steady state today raised as a result of an improvement in bank efficiency? Moreover, if I allow the elasticity of substitution between firm-owned assets and
loans to vary, how does this parameter impact the role of capital market efficiency in long-term growth? Finally, I provide the transition dynamics of the model to elucidate the mechanism through which bank efficiency exerts growth and show the welfare effect of bank efficiency.

4.1. Interpreting the diminishing capital market inefficiency

I quantify the capital market inefficiency in terms of the Euler equation wedge (WEDGE). The Euler equation represents the intertemporal consumption choices on the one hand and the capital accumulation decision on the other. When we plug data into this equation and find the gap between the right- and left-hand sides of the Euler equation, this gap is referred to as the “Euler equation wedge”. Assuming that a set of standard parameters for a Ramsey-Cass-Koopmans type of deterministic, discrete-time growth model, WEDGE indicates how far the economy departs from the ideal frictionless scenario and represents the capital market inefficiency.

There can be many explanations for the diminishing capital market inefficiency, for example, tax reduction. However, the capital tax in Taiwan is rising rather than declining (discussed in Appendix 2, illustrated as Figure 9). Therefore, I evaluate the hypothesis that an improvement in bank efficiency can account for the evolution of capital market inefficiency using the model designed in Section 2.

Since the WEDGE gauges the difference between intertemporal consumption choices and capital accumulation, I focus on equation (A1.5) and take the difference between the right- and left-hand sides of the equation as the WEDGE under the model with financial intermediation. Conceptually, a decline in the WEDGE implies improvement in capital market efficiency.

The WEDGE \((\tau_{k,t+1})\) in a simple growth model and that in a model with financial intermediation are shown as follows in equations (4) and (5) for variables in per capita terms:

\[12\] I set the capital share equal to 1/3, the depreciation rate equal to 6.5%, and the discount factor equal to 0.95.
\[ \tau_{k+1} = 1 - \frac{C_{t+1}}{C_t} \beta(r_{t+1} + 1 - \delta) \equiv 1 - \frac{LHS}{RHS} \]  

(4)

\[ \tau_{k+1}^{\text{new}} = 1 - \frac{C_{t+1}}{C_t} \beta^\text{new} \left\{ \theta \frac{Y_{t+1}}{K_{t+1}} \psi^{-\rho} \alpha \left( \frac{K_{t+1}}{K_t} \right)^{1+\rho} + 1 - \delta \right\} \equiv 1 - \frac{LHS}{\text{RHS}_{\text{bank}}} \]  

(5)

The improvement in bank efficiency accounts for the huge decline in the WEDGE during the early development phase. Figure 5 shows the comparison of the WEDGE with and without banking. As can be seen, during the early development phase, i.e., before 1980, the model taking into account the improvement in bank efficiency reduces the wedges by 53% on average \(^{13}\). However, the model does not do well in explaining the data since 1980. In other words, low capital market efficiency slows down capital accumulation when the economy is in transition during the 1960s and the 1970s and the improvement in bank efficiency has eliminated the frictions in the financial market. However, once banks are efficient enough to provide sufficient savings and lending, higher capital market efficiency does not necessarily play as beneficial a role in inducing more savings and investment. Finally, there are some other factors contributing to the WEDGE in the 1980s that can not be explained by bank efficiency improvement. This observation supports the argument regarding the impact of financial development on convergence in Aghion, Howitt and Mayer-Foulkes (2005).

4.2. The role of capital market efficiency on long-term growth

I run a counterfactual calibration, “Economy with low bank efficiency”, and compare the steady state of this counterfactual economy with the steady state of the “Economy with high bank efficiency”. These two economies are the same except that the former depicts the economy with

\(^{13}\) I only focus on the power of explanation before 1980 as various capital market reforms took place since 1980 and thus bank efficiency improvement no longer is the only factor impacting on capital market equilibrium. The model taking into account the improvement in bank efficiency reduces the wedges by 81% on average for the period before 1974.
low banking efficiency in 1961 (e=1.17) and the latter depicts the economy with the banking efficiency at the steady state (e=2.24). Any differences in outcomes between the two economies are due to the improvement in bank efficiency.

This result shows that an improvement in bank efficiency results in high steady state output when bank efficiency is high. Table 3 shows the calibrated steady states for these two economies. As can be seen, the “Economy with high bank efficiency” results in higher output (Y) than the “Economy with low bank efficiency”. Therefore, the improvement in bank efficiency causes economic growth to progress from a low to a high steady state. To be specific, the steady state output is 3.20% higher as a result of the bank efficiency improvement.

In addition, the model shows that the improvement in efficiency has a positive impact on banking-related activities: more people working in banks, more deposits, more loans and firms relying more on bank loans than self-owned assets in fostering capital. For example, the deposit to output ratio (D/Y), the loan to output ratio (L/Y), and the percentage of labor in finance (H^b / (H^b + H^f)) each rise. On the other hand, the firm-owned assets to output ratio (K^f/Y) falls and the loan to firm-owned assets ratio (L/K^f) rises when bank efficiency improves.

The active banking-related activities correspond to more savings (in terms of deposits), more accumulated capital, and thus higher output and higher returns to labor. For example, in terms of the capital to output ratio in the steady state, the “Economy with high bank efficiency” results in a higher capital-output ratio (K/Y) than the “Economy with low bank efficiency”. Moreover, households receive more labor income (w), consume more (C) and keep more deposits (D) under the “Economy with high bank efficiency” than under the “Economy with low bank efficiency”. This is because higher bank efficiency results in higher income and the household can afford to consume more and accumulate more wealth.

Firms in this model accumulate assets as well. Under the “Economy with high bank efficiency”, the loans to output ratio (L/Y) increases and the firm-owned assets to output ratio (K^f/Y) decreases.
In other words, as bank efficiency improves, firms rely more on the intermediated financing which reduces the proportion of self-financed funds and foster more capital for production.

Finally, as a result of the improvement in bank efficiency, LOAN PER EMP increases and SPREAD decreases by construction since these two variables are indicators of bank efficiency.

4.3. Sensitivity analysis on the elasticity of substitution parameter in fostering capital

I perform sensitivity analysis on $\sigma$ (elasticity of substitution between firm-owned assets and loans in fostering capital) to show how the elasticity of substitution between firm-owned assets and loans in fostering capital affect the contribution of the improvement in bank efficiency to the growth of output. Based on the modern finance theory by Modigliani and Miller, there is no optimal percentage of debt financing for a firm. Therefore, firm-owned assets and loans can not be perfect complements. On the other hand, if there are no loans, firms lose the advantage of leveraging. Therefore, I focus my sensitivity analysis on the elasticity of substitution ($\sigma$) within the range of 0.1 to 10. That is, $\sigma = 1/1 + \rho$, $\sigma \in [0.1, 10]$

Figure 6 shows the results of the sensitivity analysis based on the framework in Section 4.2 by comparing the steady state output between the “Economy with low bank efficiency” and the “Economy with high bank efficiency”. As can be seen, when firm-owned assets and loans are substitutes in fostering capital, the impact of an improvement in bank efficiency on growth is smaller than the scenario under which firm-owned assets and loans are less substitutable. This is because when firm-owned assets and loans are substitutes and when bank efficiency is low, firms can accumulate self-owned assets. In the extreme case, if firm-owned assets and loans are close to being perfect substitutes, bank efficiency will not affect capital accumulation. Then, bank efficiency improvement attracts resources that are devoted to useless financial services and thus growth is impeded.
4.4. The transitional dynamics of the model

To further investigate how an improvement in bank efficiency affects growth dynamics, I provide the transition dynamics of the model. I run simulations for two economies, i.e., “e low” and “e high”. These two economies are identical except for their bank efficiency. Economy “e low” has its bank efficiency (e) at the Taiwanese level in 1961 (e=1.17), whereas economy “e high” has its bank efficiency at the Taiwanese steady state (e=2.24). In both cases, the economies begin at the initial states of Taiwan’s economy characterized by Taiwan’s initial deposits and initial capital stock in 1961. I set the reserve requirement ratio and productivity constant at the level of the steady state for this section\textsuperscript{14}, so that I can focus on the relationship between the bank’s operating efficiency and growth.

In the experiment, I observe the transition dynamics for output (Y), capital used in production (K), output growth (g_y), capital growth (g_K), the private saving rate (1-\frac{C}{r^D + wH}), the national saving rate (1-\frac{Y}{C}), and the firm’s financing choices (\frac{K^f}{K^f + L}). I would like to verify whether bank efficiency impacts growth by efficiently reallocating resources or by altering saving rates.

Figure 7 shows the simulated transitional dynamics for output and capital. I also compute the growth rates of output and capital over time. As can be seen, for output and the capital stock, economy “e high” has higher transition paths than economy “e low” throughout the entire period. The related output growth and capital growth shows that economy “e high” performs better than economy “e low” in general\textsuperscript{15}. However, its size is small in the long run: The growth difference disappears once both economies attain their steady states.

I also look at the saving behavior of both households and firms. Figure 8 shows the transitional dynamics for the private saving rate (one minus the consumption to total household income ratio),

\textsuperscript{14} The simulation with different sets of reserve requirement ratio and productivity yields similar results.

\textsuperscript{15} The effect is ambiguous during the very early development phase when assuming different productivity levels at the steady state.
the firm’s financing choices, and the national saving rate. As can be seen, the households are willing
to save more under high bank efficiency. However, in terms of the firm’s financing choices, I find
that firms rely more on external financing in economy “e high” than in “e low”. Moreover, the
transitional dynamics from below the steady state to the steady state shows that firms lower their
self-financing ratio as they converge to the steady state which implies that firms rely more on
intermediated funds as the economy grows. This result coincides with Gurley and Shaw’s finding
regarding the firm’s financing choices during growth.

As to the aggregate saving rate, which is defined as one minus the C/Y ratio, the transitional
dynamics shows that the saving rate is higher in economy “e high” than in economy “e low” when it
is below the steady state. However, the difference is found to decline over time with the result that
the saving rate in economy “e high” becomes smaller than that in economy “e low” as its converges
to the steady state. This is because the firms’ saving choices dominate the households’ saving
choices at the steady state in this model. Therefore, we observe the ambiguous effect of an
improvement in bank efficiency on the saving rate. This implies that altering saving rates is not a
necessary channel for financial development to impact growth. This result quantitatively supports
Beck, Levine and Loayza (2000) empirical result that saving behavior is ambiguously related to
growth.

Finally, I analyze the welfare effect of bank efficiency improvement. Following Lucas (1987,
2003), I compute $\lambda$, which characterizes the percentage of extra consumption required uniformly
across all dates for agents to be indifferent to stay under either high or low bank efficiency. That is,
for $u_H$ representing the utility under high bank efficiency and $u_{equiv}$ representing the equivalent
utility under low bank efficiency, $\left\{ \sum_{t=1}^{\infty} u_H(C_{H,t}, H_{H,t}) = \sum_{t=1}^{\infty} u_{equiv}(C_{L,t}(1 + \lambda), H_{L,t}) \right\}$. For the
experiment in this section, I find $\lambda$ to be equal to 2.58%. In other words, the agent is indifferent to
either high or low bank efficiency if the mean consumption growth is about 2.58% higher under low bank efficiency. Therefore, high bank efficiency is welfare enhancing.

The results of this paper are consistent with those of Gurley and Shaw (1955) in that investment switches its source of finance from un-intermediated to intermediated financing during growth. Moreover, my result shows that financial intermediary development has a positive level effect on output and capital, but has an ambiguous effect on the saving rate. This result is similar to Beck, Levine and Loayza (2000) in that both of us argue the ambiguous effect on the saving rate. However, Beck, Levine and Loayza suggest that high bank efficiency results in a positive effect on output growth and an ambiguous effect on capital growth whereas I show that high bank efficiency results in higher output and capital growth (except the very early development phase). Nevertheless, my findings support the view that when financial intermediaries perform efficiently, domestic resources are efficiently mobilized through the financial sector and then have a positive impact on economic growth in general. Finally, an improvement in bank efficiency is welfare enhancing in the long run.

5. Conclusion

This study quantitatively evaluates the hypothesis that financial development can account for the evolution of capital market inefficiency in economies experiencing rapid growth and evaluates how good financial development is a tool in exerting growth. I use the case of Taiwan (1961-2005) to evaluate these issues.

The hypothesis is motivated by the fact that bank efficiency has improved significantly over time since the 1960s and its pattern coincides with the declining capital market inefficiency, which is measured by the Euler equation wedge. Moreover, this hypothesis coincides with the well-known empirical evidence in the development literature regarding the positive impact of financial development on growth. (Bank/Capital market efficiency improves as a result of financial
Therefore, to explain the declining Euler equation wedges and to quantitatively address the issue regarding the role of financial development in economic growth, I construct a model with financial intermediation to quantitatively study these issues.

The model used to study bank efficiency and growth is developed based upon a prototype neoclassical growth model. In addition to agents’ CES preference for consumption and leisure, and firms’ Cobb-Douglas production technology to produce outputs, I added three more features to the model. First, there are banks receiving agents’ savings and providing loans to firms. Second, banks own a Cobb-Douglas technology that converts deposits and labor into loans. Finally, with a CES technology, firms combine intra-temporal borrowing and firm-owned assets to produce capital, which firms put into production.

I use the Taiwan case to calibrate the parameters and solve for steady states. In my model, 53% of the Euler equation wedge before 1980 can be explained using the new model. This implies that the capital market efficiency improvement mitigates frictions in the capital market and thus partially explains the growth path in Taiwan. In other words, financial development improves capital market efficiency and relaxes the financing constraint on capital accumulation and thus impacting on growth in Taiwan in the 1960s and 1970s.

I also analyze the role of an improvement in bank efficiency on transition dynamics and long-term growth and identify the mechanism through which financial development exerts growth. The steady state analysis shows that when bank efficiency is high, the corresponding output at the steady state is high as well given a set of parameters (e.g., the parameters for Taiwan). The growth effect vanishes and turns negative as the substitutability increases. Therefore, efficient financial intermediation can (but does not always) exert a positive impact on long-term economic growth.

The transitional dynamics shows that an improvement in bank efficiency has a positive impact on output, capital, output growth, and capital growth in general. Moreover, the effect on the saving rate is ambiguous – households save more, but firms save less as bank efficiency improves.
Consequently, the two opposite forces lead to a small and ambiguous effect on the national saving rate during a time of economic transition. Therefore, the Taiwanese case supports the result in Beck, Levine and Loayza (2000) that financial development leads to an ambiguous effect on saving rates. Nevertheless, my paper also supports the view that capital market efficiency positively impacts growth through the efficient mobilization of funds savers to firms rather than by altering the saving rate.

In addition, I find that firms rely more on un-intermediated funds when bank efficiency is low and switch to intermediated funds as bank efficiency improves during the growth process. That is, firms tend to take advantage of financial development and rely more on intermediated funds. This conclusion is similar to Gurley and Shaw’s (1955) observation regarding firms’ financing choices during growth. Finally, based on the welfare analysis, the improvement in bank efficiency is welfare enhancing in the long run.

Finally, since the degree to which bank efficiency affects growth is sensitive to the elasticity of substitution between firm-owned assets and loans, other research could be done to study this elasticity of substitution from a micro prospective. This paper then leads to research concerning issues in corporate finance that have to do with a firm’s financial structure. Once the elasticity of substitution for the firms’ financing is estimated, the importance of financial development to growth can be accurately assessed. Then, one is in a better position to provide useful policy recommendations to the developing world regarding financial development.
Appendix 1: The Equilibrium

A competitive equilibrium of the model in Section 2 is derived as follows (from A to D):

A) Given that the population grows deterministically at rate \( \nu \), and \( n_t = (1 + \nu)^t \), I divide all variables by \( n_t = (1 + \nu)^t \) so as to obtain stationary, per capita, values for all terms.

B) Given the labor-augmented technology which grows at rate \( g \), I detrend all the variables by \( (1 + g)^t \).

C) The stationary version of the model as a competitive equilibrium is presented below after defining the detrended per capita variables as follows\(^{16}\):

\[
\tilde{H}_t^b = \frac{H_t^b}{(1 + \nu)^t}; \quad \tilde{H}_t^f = \frac{H_t^f}{(1 + \nu)^t}; \quad \tilde{H} = \frac{\hat{H}_t}{(1 + \nu)^t}; \quad \tilde{h}_t^b = \frac{h_t^b}{(1 + \nu)^t}; \quad \tilde{h}_t^f = \frac{h_t^f}{(1 + \nu)^t}; \quad \tilde{H} = \frac{H_t}{(1 + \nu)^t};
\]

\[
\tilde{Y}_t = \frac{Y_t}{(1 + \nu)^t(1 + g)^t}; \quad \tilde{C}_t = \frac{C_t}{(1 + \nu)^t(1 + g)^t}; \quad \tilde{\bar{w}}_t = \frac{\bar{w}_t}{(1 + g)^t};
\]

\[
\tilde{K}_t = \frac{K_t}{(1 + \nu)^t(1 + g)^t}; \quad \tilde{k}_t = \frac{k_t}{(1 + \nu)^t(1 + g)^t}; \quad \tilde{K}_t^f = \frac{K_t^f}{(1 + \nu)^t(1 + g)^t}; \quad \tilde{k}_t^f = \frac{k_t^f}{(1 + \nu)^t(1 + g)^t};
\]

\[
\tilde{L}_t = \frac{L_t}{(1 + \nu)^t(1 + g)^t}; \quad \tilde{l}_t = \frac{l_t}{(1 + \nu)^t(1 + g)^t}; \quad \tilde{L}_t = \frac{\hat{L}_t}{(1 + \nu)^t(1 + g)^t}; \quad \tilde{l}_t = \frac{\hat{l}_t}{(1 + \nu)^t(1 + g)^t};
\]

\[
\tilde{D}_t = \frac{D_t}{(1 + \nu)^t(1 + g)^t}; \quad \tilde{d}_t = \frac{d_t}{(1 + \nu)^t(1 + g)^t}; \quad \tilde{D}_t = \frac{\hat{D}_t}{(1 + \nu)^t(1 + g)^t};
\]

D) To obtain the competitive equilibrium, I take the following steps (from a to g):

- a) Given \( \{w_t, r_t^L\}_{t=0}^{\infty} \), \( K_t, L_t \) and \( H_t \) solve the firms’ problem:

\[
\begin{align*}
\text{Max} \quad & \pi_t = \sum p_i \left\{ f(H_t^f, g(K_t^f, L_t)) - w_t H_t^f - r_t^L L_t - [K_{t+1} - (1-\delta)K_t^f] \right\} \\
s.t. \quad & f(H_t^f, g(K_t^f, L_t)) = Z_t K_t^{\delta}(x_t H_t^f)^{1-\delta} = Y_t \\
& g(K_t^f, L_t) = \Psi[\alpha K_{t+1}^{\sigma} + (1-\alpha) L_t^{\sigma}]^{1-\sigma} = K_t
\end{align*}
\]

- b) Given \( \{w_t, r_t^L, r_t^D\}_{t=0}^{\infty} \), \( D_t, L_t \) and \( H_t \) solve the banker’s problem\(^{17}\):

---

\(^{16}\) The variables with ‘\(^b\)’ represent the values determined by the supply side of the markets. The variables with upper case are based on an aggregated concept. The superscript ‘\(^f\)’ refers to firms and ‘\(^b\)’ refers to banks.
c) The representative family maximizes utility given \( \{w_t, r_t^D\}_{t=0}^\infty \)

\[
\begin{align*}
\text{Max} & \quad \pi_t^b = r_t^b \hat{L}_t - r_t^D D_t - H_t^b w_t \\
\text{s.t.} & \quad \hat{L}_t = \epsilon_t \left( (1 - \gamma) D_t \right) \left( x_t^b H_t^b \right)^{1-\theta}
\end{align*}
\]

\[
\begin{align*}
\text{Max} & \quad \left\{ u(C) = \sum_{i=0}^\infty \beta^i \left\{ \log(C_t) + \phi \log(1 - \hat{H}_t) \right\} \right\} \\
\text{s.t.} & \quad \sum p_t [C_t + \tilde{D}_{t+1} - \tilde{D}_t] \leq \sum p_t [w_t \hat{H}_t + r_t^D \tilde{D}_t + \pi_t]
\end{align*}
\]

d) Market clearance conditions:
\[
\begin{align*}
L_t &= \hat{L}_t \\
D_t &= \tilde{D}_t \\
H_t &= \hat{H}_t
\end{align*}
\]

There are three factor markets in this economy: capital markets (lending and borrowing) and the labor market. Therefore, I set three market clearing conditions in equilibrium. The capital market clears at price \( r_t^L \) for loans and \( r_t^D \) for deposits; the labor market clears at wage \( w_t \) and the resource constraint is satisfied.

e) Resource constraint:
\[
\begin{align*}
C_t + [D_{t+1} - D_t] + [K_{t+1}^f - (1 - \delta) K_t^f] & \leq Z_t K_t^{\theta/\gamma} (x_t H_t^f)^{1-\theta} \\
H_t^f + H_t^b & \leq H_t \leq 1
\end{align*}
\]

f) Law of motion:
\[
x_t = (1 + g)' \]

g) The system of equations

Therefore, the competitive equilibrium for an undistorted system is: A sequence of quantities \( \{Y_t, K_t, H_t^f, K_t^f, L_t, D_t, H_t^b, H_t, C_t\}_{t=0}^\infty \), and a sequence of prices \( \{w_t, r_t^L, r_t^D\}_{t=0}^\infty \) such that the representative family and firm optimize and markets clear.

The system of equations (equations A1.1 to A1.12) that characterize the equilibrium in terms of the detrended variables is as follows:

\[
\tilde{Y}_t = Z_t (x_t \hat{H}_t^f)^{1-\theta} \hat{K}_t^\theta
\]  \quad (A1.1)

\footnote{Similar setup for the banking sector which maximize bank profit under a perfectly competition environment can also seem in Chang et al. (2007).}
\( \ddot{K} = \Psi \left\{ \alpha (\ddot{K}^f)^\rho + (1 - \alpha) (\dddot{L})^{-\rho} \right\} \)  
(\text{A1.2})
\[
\ddot{L} = e_0 (1 - \gamma) \dddot{D} (x_0 \dddot{H}^b)^{1-\eta} \]  
(\text{A1.3})
\[
\dot{r}_L = \theta \frac{\dddot{Y}}{\dddot{L}} \Psi^{-\rho} (1 - \alpha) \left( \frac{\dddot{K}}{\dot{L}} \right)^{1+\rho} \]  
(\text{A1.4})
\[
\left( \frac{\dddot{C}_{t+1}}{\dddot{C}} \right) \cdot (1 + g) = \beta \left( \theta \frac{\dddot{Y}_{t+1}}{\dddot{K}_{t+1}} \Psi^{-\rho} \left( \frac{\dddot{K}_{t+1}}{\dddot{K}^f} \right)^{1+\rho} + 1 - \delta \right) \]  
(\text{A1.5})
\[
\dddot{w}_t = (1 - \theta) \frac{\dddot{Y}}{\dddot{H}^f} \]  
(\text{A1.6})
\[
\dddot{r}_D = \dddot{r}_L \eta \left( \frac{\dddot{L}}{\dddot{D}} \right) \]  
(\text{A1.7})
\[
\dddot{w}_t = \dddot{r}_L (1 - \eta) \left( \frac{\dddot{L}}{\dddot{H}^b} \right) \]  
(\text{A1.8})
\[
\dddot{w}_t = \frac{\phi}{\dddot{C}} \frac{1}{1 - \dddot{H}} \]  
(\text{A1.9})
\[
\left( \frac{\dddot{C}_{t+1}}{\dddot{C}} \right) \cdot (1 + g) = \beta (\dddot{r}^D_{t+1} + 1) \]  
(\text{A1.10})
\[
\dddot{Y}_t = \dddot{C} + [(1 + v)(1 + g) \dddot{D}_{t+1} - \dddot{D}] + [(1 + v)(1 + g) \dddot{K}^f_{t+1} - (1 - \delta) \dddot{K}^f] \]  
(\text{A1.11})
\[
\dddot{H}_t = \dddot{H}^f + \dddot{H}^h \]  
(\text{A1.12})

There are 12 equations and 12 unknowns. This system of equations (A1.1-A1.12) represents the steady state conditions of the economy along the balanced growth path.
Appendix 2: Alternative possible explanation for the Euler equation

One common explanation for the declining wedges is tax reduction (e.g., Mulligan). Mulligan (2004) finds that capital taxation drives a wedge between consumption growth and the expected pretax return and that the tax is the major distortion in the capital market. Therefore, he provides one possible explanation for the Euler equation wedge. Therefore, I follow Mendoza, Razin and Tesar (1994) and Mulligan (2003) and come up with a series of capital taxes for Taiwan from 1961 to 2005. I define the capital tax rate ($\tau$) as follows:

$$\tau_t \equiv \frac{T_t + P_t}{R_t + P_t}$$

All the variables are in real terms. $T_t$ is the sum of the corporate income tax revenue plus the capital share (1/3) of the individual tax revenue\(^{18}\). $P_t$ is the sum of the taxes on land, housing and on securities transactions. $R_t$ is the total capital income net of indirect tax, calculated as $(Y - Y_g)[\frac{NI - W_g - W_p}{NI - W_g}]$ multiply the ratio of $\frac{GDP \text{ at basic price}}{GDP \text{ at market price}}$. The formula follows Mulligan (2003) except that I drop $Y$s in his formula since there are no such data in Taiwan and so I assume it to be zero. $Y$ is net domestic product, $Y_g$ is the net domestic product of the government sector, $NI$ is national income, $W_g$ is the labor compensation of government employees and $W_p$ is the labor compensation of employees in private sector (including public enterprises) which equals to $2/3$ of the labor compensation plus the operating surplus.

Figure 9 shows the computed capital tax. As can be seen, the computed capital tax rate has been rising for the majority of the time. This pattern contradicts what is implied by the Euler equation wedges for the Taiwanese case. Therefore, I turn to the literature on economic development and seek an alternative explanation. The main themes I focus on to explain the declining Euler equation wedge is the bank efficiency improvement in Taiwan.

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\(^{18}\) I do not use the Adjusted Gross Income due to the fact that the U.S. and Taiwan apply different tax forms and rules.
Appendix 3: Banking Efficiency Indicators

“Financial Sector Assessment, a Handbook,” a joint work by the World Bank (WB) and the International Monetary Fund (IMF) suggests that the Interest rate spread (SPREAD) is one of the indicators for the efficiency of financial system performance. In addition, I suggest one more indicator – loans made per employee in finance (LOAN PER EMP). In this section, I discuss these two indicators.

A 3.1 SPREAD

SPREAD is often employed as a measure of the severity of frictions in financial markets. According to the World Development Indicators, SPREAD is defined as “the interest rate charged by banks on loans to prime customers (lending rates) minus the interest rate paid by commercial or similar banks for demand, time, or saving deposits.(deposit rates).” Efficient financial intermediation tends to correspond to a small SPREAD.

For the case of Taiwan, the interest rate spread (SPREAD), which is the lending rate\(^{19}\) minus the 30-day deposit rate, has declined from around 11% to around 2% (in 2006). This long-term trend is completely different from the US pattern. Figure 2 shows the Taiwanese SPREAD (1961-2005) relative to the U.S. SPREAD (1965-2005). As can be seen, the declining trend for the Taiwanese SPREAD is big relative to the U.S. SPREAD which fluctuates around 2% (slightly lower in the 1960s and the 1970s and higher in the 1990s by 1 percentage point). This implies that bank efficiency has improved in Taiwan and has experienced no significant changes in the U.S.

A3.2 Ratio of real loans per employees (LOAN PER EMP)

The ratio of real loans to the number of employees in finance indicates the efficiency of a banking system. This ratio is analogous to average labor productivity if loans are a bank’s only

\(^{19}\) I used the average of the collateral loan rate and prime rate as the lending rate. This is because the collateral loan rate is lower than the prime rate in Taiwan. The difference is highly correlated with the nonperforming loan ratio. The correlation coefficient equals 0.7981 for the period from 1991 to 2005. Therefore, I use the average of the prime rate and the collateral loan rate to represent the risk-free lending rate in Taiwan and to compare it with the prime rate in the U.S.
output. When there are more loans made per employee, the bank is more efficient in intermediating funds from savers to investors\textsuperscript{20}.

Figure 7 shows the number of employees required to make US$1 billion in real loans (inverse of LOAN PER EMP) for Taiwan and compares it with that for the U.S. (1961-2000). As can be seen, for Taiwan, the number of employees declined from 13,312 to 398 by 1994 and then fluctuated around 392 and 413. Therefore, LOAN PER EMP shows that banking efficiency has risen significantly since 1961. The labor efficiency in the banking system in 2000 is about 30 times what it was in 1961\textsuperscript{21}. I show the same indicator for the US from 1961 to 2000 in the same graph to show how significant the improvement is in Taiwan. As can be seen, the number of employees needed to provide $1 billion in loans in the U.S. falls from 1,866 to 909 over the 40-year period. Such a decline implies that labor efficiency in the banking system in 2000 is about twice that in 1961. Therefore, the banking efficiency improvement in Taiwan is significant compared with that in the U.S.

\textsuperscript{20} To the best of my knowledge, non-performing loans is not an issue for the Taiwanese case.

\textsuperscript{21} I made assumptions for the number of employees in finance relative to services in 1951 and conjectured the percentage of labor in the financial sector from 1961 to 1977 relative to the service sector. Please refer to Appendix 4 for a detailed description.
Appendix 4: Extending the series: labor in finance (1961-1978)

The Directorate-General of Budget, Accounting and Statistics, Executive Yuan, R.O.C (DGBAS, Taiwan) started to report the number of employees in finance in 1978. To extend the series back to 1961, I make an assumption for the percentage of employees in finance relative to services in 1951. Then, I assume that the ratio remained linear and experienced equal-spaced increments from 1951 to 1978 (the year with data). Finally, I multiply that ratio by the number of employees in services (available in the dataset) to obtain the number of employees in finance.

The series (1978-2005) for the employees in finance to services ratio is relatively stable (from 2.48% to 3.58%) compared with the series for finance relative to total employees (from 0.88% to 2.06%). Since the percentage of labor in services relative to total employees exhibits the same upward sloping trend (35.6% to 57.7%) as the latter, I assume that the trend for the latter is mostly attributed to the increasing percentage of workers in services. Therefore, I assume that the percentage of employees in finance relative to services remains constant.

Since the number of employees in finance relative to services is 2.48%, I show three cases and assume that the ratios in 1951 are 0.1%, 1%, and 2.48% for cases one to three, respectively. Notice that the first case is an extreme case – 0.1% of the labor in finance relative to services corresponds to 781 people working in the financial sector (in 1951, there were a total of 2,893,000 employees in the economy as a whole). Despite the extreme assumption, the corresponding LOAN PER EMP in 1961 remains less than 1/10 of the productivity in 2002. At the other extreme, 2.48% of employees in finance relative to services correspond to 19,000 people working in the financial sector. The corresponding LOAN PER EMP in 1961 is less than 1/30 of the productivity in the 2000s. I present the results of the sensitivity analysis in Table 4 below.

<table>
<thead>
<tr>
<th>Percentage of service employees in finance</th>
<th>Number of employees for $100 million real loans made in 1961</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10%</td>
<td>17</td>
</tr>
<tr>
<td>1%</td>
<td>27</td>
</tr>
<tr>
<td>2.48%</td>
<td>43</td>
</tr>
</tbody>
</table>
Literature Cited


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Data Sources:

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Available at http://www.cbc.gov.tw/economic/statistics/key/total_02.asp


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Table 1: Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \theta )</td>
<td>1/3</td>
<td>capital share</td>
</tr>
<tr>
<td>( \nu )</td>
<td>1.1%</td>
<td>population growth</td>
</tr>
<tr>
<td>( g )</td>
<td>2%</td>
<td>technological growth (world average)</td>
</tr>
<tr>
<td>( \delta )</td>
<td>6.5%</td>
<td>depreciation</td>
</tr>
<tr>
<td>( \phi )</td>
<td>0.8587</td>
<td>coefficient for leisure in the agent's utility</td>
</tr>
<tr>
<td>( \beta )</td>
<td>0.9948</td>
<td>discount factor</td>
</tr>
<tr>
<td>( \rho )</td>
<td>-0.5976</td>
<td>( \rho ): substitution parameter for the firm capital CES function (( \sigma=2.4850 ) elasticity of substitution between firm-owned assets and loans)</td>
</tr>
<tr>
<td>( \alpha )</td>
<td>0.7255</td>
<td>income share parameter for the firm capital CES function</td>
</tr>
<tr>
<td>( \psi )</td>
<td>0.7715</td>
<td>scalars of CES functions for firm capital</td>
</tr>
<tr>
<td>( \eta )</td>
<td>0.8020</td>
<td>income share parameter for the bank Cobb-Douglas function</td>
</tr>
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</table>

Table 2: “Data” versus “Model”

<table>
<thead>
<tr>
<th></th>
<th>C/Y</th>
<th>K/Y</th>
<th>L/Y</th>
<th>D/Y</th>
<th>Hf</th>
<th>Hb</th>
<th>rL</th>
<th>rD</th>
<th>rL –rD</th>
<th>L/Hb</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS in Data</td>
<td>0.6530</td>
<td>1.9135</td>
<td>1.3174</td>
<td>2.0980</td>
<td>0.5374</td>
<td>0.0106</td>
<td>4.76%</td>
<td>2.54%</td>
<td>2.22%</td>
<td>50683</td>
</tr>
<tr>
<td>SS in Model</td>
<td>0.6497</td>
<td>1.8945</td>
<td>1.1672</td>
<td>1.8538</td>
<td>0.5393</td>
<td>0.0094</td>
<td>5.03%</td>
<td>2.54%</td>
<td>2.49%</td>
<td>50680</td>
</tr>
</tbody>
</table>

C/Y: Consumption-to-output ratio; K/Y: Capital-to-output ratio; D/Y: Deposit-to-output ratio; L/Y: Loan-to-output ratio; Hf: Labor in firms (Max=1); Hb: Labor in banks (Max=1); rL: Lending rate; rD: Deposit rate; rL –rD: Interest rate spread; L/Hb: Loans per bank employee

Table 3: The steady states’ directions of change and size of impacts when bank efficiency improves (in a high productivity economy)

<table>
<thead>
<tr>
<th></th>
<th>Y</th>
<th>K/Y</th>
<th>C/Y</th>
<th>L/Y</th>
<th>Kf /Y</th>
<th>LOAN PER EMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economy with low bank efficiency</td>
<td>395.40</td>
<td>1.754</td>
<td>0.647</td>
<td>0.263</td>
<td>3.409</td>
<td>25592</td>
</tr>
<tr>
<td>Economy with high bank efficiency</td>
<td>408.03</td>
<td>1.895</td>
<td>0.650</td>
<td>1.163</td>
<td>3.039</td>
<td>50680</td>
</tr>
</tbody>
</table>

% change due to higher bank efficiency

<table>
<thead>
<tr>
<th></th>
<th>↑ or ↓</th>
<th>rL</th>
<th>Hb/Hb + Hf</th>
<th>W</th>
<th>D/Y</th>
<th>L/Kf</th>
<th>SPREAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economy with low bank efficiency</td>
<td>3.20%</td>
<td>8.03%</td>
<td>0.40%</td>
<td>343%</td>
<td>10.84%</td>
<td>98.03%</td>
<td></td>
</tr>
<tr>
<td>Economy with high bank efficiency</td>
<td>9.58%</td>
<td>0.74%</td>
<td>485</td>
<td>0.798</td>
<td>7.74%</td>
<td>7.04%</td>
<td></td>
</tr>
</tbody>
</table>

“% change” due to higher bank efficiency

<table>
<thead>
<tr>
<th></th>
<th>↑ or ↓</th>
<th>rL</th>
<th>Hb/Hb + Hf</th>
<th>W</th>
<th>D/Y</th>
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<th>SPREAD</th>
</tr>
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<td>9.58%</td>
<td>0.74%</td>
<td>485</td>
<td>0.798</td>
<td>7.74%</td>
<td>7.04%</td>
<td></td>
</tr>
<tr>
<td>Economy with high bank efficiency</td>
<td>5.03%</td>
<td>1.71%</td>
<td>504</td>
<td>1.854</td>
<td>38.41%</td>
<td>2.49%</td>
<td></td>
</tr>
</tbody>
</table>

Direction of impacts (↑ or ↓) due to an improvement in bank efficiency: ↑: increases; ↓: decreases
Figure 1: Euler equation wedge U.S. vs. Taiwan: The pattern in Taiwan is different from that of the U.S.

Figure 2: SPREAD: U.S. (1965-2005) vs. Taiwan (1961-2005): The decline of the SPREAD in Taiwan is dramatic.

Figure 3: The number of employees needed for a $1 billion real loan in the U.S. and Taiwan (1961 - 2000): The bank efficiency improvement in Taiwan is significant compared with that in the U.S.
Interest rate spread vs. Euler equation wedge

Figure 4: SPREAD (difference between lending and deposit interest rate) vs. Euler equation wedge: SPREAD and WEDGE are highly correlated.

Euler Equation Wedges

Figure 5: Euler equation wedges: vanilla model (Old, without banking) vs. model with financial intermediation (New, with banking): Model with financial intermediation reduced the Euler equation wedge during the early development phase.

Sensitivity Analysis for Elasticity of Substitution (Sigma) on Output Growth

Figure 6: Sensitivity analysis for $\sigma$ and its impact on output growth: High substitutability between firm-owned assets and loans reduces the impact of bank efficiency improvement on growth.
Figure 7: Transition dynamics for output and capital:

High bank efficiency results in high output and capital as well as their high growth rates.

Figure 8: Transitional dynamics related to savings: the impact on the saving rate is ambiguous.

Figure 9: Computed capital tax rate from 1961 to 2005:

A tax reduction can not be an explanation for the declining Euler equation wedge in Taiwan.