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Does importing more inputs raise productivity and exports? Some evidence from Indian manufacturing

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ABSTRACT

This study aims to analyse the role of imported inputs on productivity and export performance of the manufacturing industries of India. Our results indicate that imported inputs are crucial determinates of Total Factor Productivity (TFP). However, the impact varies greatly across industries. Furthermore, results regarding research and development (R&D) intensity suggest that in-house R&D activities do not play a significant role in the productivity performance of Indian manufacturing firms. Our results also indicate that imports lead to a substantial growth in exports. In particular, exports in the chemical, machinery and transport equipment industries are highly dependent on imported intermediate goods. The results also indicate that although R&D is not linked with the productivity of industries, it has an important role in the export performance of these industries. TFP is also estimated to have a significant and sizable impact on export performance. This, in turn, supports the self-selection hypothesis, which explains the self-selection of more productive firms into the export market. Overall, our results support both hypotheses: learning by importing and self-selection in the import market.

1. INTRODUCTION

Imported inputs are considered a crucial factor in various trade and growth models. These models advocate that firms gain from international trade in general, and imports in particular, through better access to otherwise unavailable inputs. The gain for firms from importing could be static and dynamic (e.g. see Coe and Helpman 1995; Barro 1997; Frankel and Romer 1999). The use of imported inputs has also increasingly become a channel for obtaining new technologies, which in turn enhances industrial productivity. Since developing countries lack in original research and development (R&D),

the adoption and simulation of technologies through the import route has become a crucial source of technological enhancement in these countries.

However, empirical findings on this issue are very mixed. For example, recent studies by Amiti and Konings (2007), Jones (2008), Kasahara and Rodrigue (2008), Goldberg *et al* (2010), Sharma (2014) and Halpern *et al* (2015), have found a significant role for imports or imported intermediate inputs in explaining the productivity growth of domestic firms. Contrary to this, Lawrence and Weinstein (1999), Van Biesebroeck (2003), and Muendler (2004) have shown insignificant or modest impacts from this activity.

In recent years, imported inputs have become a key source of high export growth, especially for developing countries. For instance, Hummels *et al* (2001) have shown that vertical integration accounted for 21 per cent of emerging countries' exports. The findings of Anós-Casero and Astarloa (2010) suggested that the contribution of imported inputs was around 14.5 percent in Argentina's total exports in the year 1997. Recently, Lo Turco and Maggioni (2013) for Italian manufacturing, and Aristei *et al* (2013) for European countries, found a crucial dependency of exporting on importing. In the theoretical literature too, the export-import linkage is widely discussed and shown to be strongly interlinked (e.g. Herander and Thomas 1986; Wonnacott and Wonnacott 2005). However, in the case of India, one of fastest and largest emerging economies, the issue is under-represented in the standard literature. Thus, given a solid theoretical inter-linkage between importing and exporting, there is a need to explore the role of imported inputs in the country's export performance.

This issue is important from a policy standpoint, as several economists in the country have proposed pursuing an export-oriented trade policy, especially through exchange rate intervention (for a detailed discussion, see Bhanumurthy and Sharma 2013). Some researchers (e.g. Lawrence and Weinstein 1999) argue that because of a lack innovation activities in the industries of developing countries, imported goods are an important source of learning. Imports also perform a crucial role in determining the export performance of industries. Therefore, a currency depreciation aimed at augmenting the exports and restricting the imports of a country, will not serve any great purpose, as exports are vitally dependent on imports.

Against this backdrop, we have twin objectives in this study. First, we test the effects of imported inputs on productivity. Second, we analyse the role of imported inputs on the export performance of the country. For the productivity-enhancing effects of imports, we test 'learning-by-importing'; and for more productive effects on importing, we examine the 'self-selection' hypothesis (for details, see Vogel and Wagner 2010). In doing so, we introduce several novelties. First, while the related literature on India is focused mainly on the export-productivity linkage (e.g. see Sharma and Mishra 2011), we focus on import-productivity and import-export linkages. Our findings will therefore be helpful in designing more beneficial exchange rate, trade and industrial policies.

Furthermore, to promote exports through imported inputs, the government has given several exemptions on duties for exporters in India importing inputs (see FTP 2009). Over time, observers and experts have raised questions on the relevance and effectiveness of such policies and schemes (e.g. Topalova and Khandelwal 2011), as it is argued that this hurts local industries and causes revenue loss. Our findings will help in understanding the relevance of such policies. Second, in most of the previous studies in this area focusing on India, data from the annual survey of industry (ASI) database have been used. We utilise a relatively new manufacturing database, Prowess, which includes firm level data for eight important industries. It also allows us to extend the time horizon of the study up to 2011. This dataset is rich and provides detail on heterogeneity in terms of trade and R&D across industries as well as over time. Considering the attractive properties of this database, some recent studies, e.g. Goldberg *et al* (2010), De Loecker *et al* (2012) and Sharma (2014), have used this database.

However, instead of using firm-level data, we opt for the industry-level data for the analysis as we are interested mainly in understanding the relationship at the industry-level (aggregate-level). By doing so, we are able to consider all firms in the database (more than 15000) in the analysis, while studies using firm-level data have been restricted to using a much smaller sample size because of data related constraints, such as, missing information on number of workers of a large number of firms. Furthermore, the main advantages of a firm-level analysis are the use of important information of firms such as entry-exit, competition and pricing. Prowess, however, does not provide this information. Therefore, the use of aggregate, industry-level data, seems to be advantageous in our case. Third, most of the previous studies have directly applied ordinary least squares (OLS) and have not paid serious attention to the time series properties of the temporal data i.e., (non-) stationarity of the variables, which can result in biased results.

Therefore, given the well-known fact that non-stationarity of data series causes various estimation problems, we utilise unit root tests and cointegration techniques to test the integration between variables in the panel context. For the estimation, we use Fully Modified OLS (FMOLS) and System Generalised Method of Moments (Sys-GMM), which are likely to produce better results than the traditional estimators, by taking care of endogeneity problems in the estimation analysis. It also allows us to use the variables in the level form in the analysis rather than their growth rates and therefore, avoids any information loss from the use of first differences. *Finally*, the recent trends suggest that the government is specifically focusing on enhancing R&D activities by providing a series of fiscal incentives and financial support. Therefore, it is important to know the role of R&D in productivity enhancement as well as on exporting performance.

The rest of the paper is organised as follows: Section 2 presents the background theory and review of the literature. Section 3 discusses data-relat-

ed issues and TFP estimation methodology. Section 4 discusses empirical models and methodologies. In Section 5, we discuss our empirical results. Finally, section 6 presents the main findings and conclusions of the study.

2. THE THEORETICAL LINKAGE AND REVIEW OF THE RELATED LITERATURE

A growing body of theoretical work, well supported by empirical studies in international economics, suggests that foreign trade has large positive effects on income, output and productivity (Romer 1987; Coe and Helpman 1995; Barro 1997; and Frankel and Romer 1999). The role of imported intermediate inputs is understood to be particularly vital and that is why, in recent years, it has attracted considerable attention in the standard literature: how do intermediate goods affect productivity? Importing and the performance of industry are integrated in several ways. First, better and easier access to imported intermediates can improve performance and productivity, because foreign intermediate inputs are generally of better quality. Second, it can also improve productivity through the production equivalent of a 'love-of-variety' (Ethier 1982). Third, endogenous growth models emphasise the important role of importing new varieties of inputs. It is shown in the theoretical literature that new varieties of inputs lead to a significant productivity improvement of firms, both in the short as well as in the medium term (Romer 1987; Rivera-Batiz and Romer 1991). Fourth, foreign competition in the final goods market can also augment the productivity of domestic producers attributable to an X-inefficiency effect: trade yields welfare gains by inducing an increased supply of a non-contractible factor, which initially is socially under-supplied (e.g. Horn *et al* 1995).

Fifth, a decline in the prices of intermediate inputs may lead to a decrease in the markup accompanied by a scale effect (Krugman 1979; Helpman and Krugman 1985; Bernard *et al* 2003). Sixth, an increase in the speed of technology adoption through a reduction in the number of domestic firms (Ederington and McCalman 2008) can also help domestic firms to enhance their productivity. However, foreign competition in the final-goods market can occasionally reduce firm productivity by slowing the rate at which new technology is adopted, by reducing the domestic firm's market share (Rodrik 1992; Miyagiwa and Ohnon 1995; Ederington and McCalman 2008). Finally, productivity can also increase through a reallocation effect, where less productive domestic firms exit the market and more productive domestic firms gain their market shares (e.g. see Melitz 2003).

The knowledge spillovers between foreign and domestic firms through imported inputs could be a crucial channel (e.g. Keller 2004). In Eaton and Kortum's (1999) model, trade including imports augments the production possibilities for the classic Ricardian reasons, such as trade providing access to foreign goods or, implicitly, technologies. By specialising in their respective comparative advantage goods, countries can gain from trade in the sense that, given a country's resources, the efficient level of output with trade is higher

than without trade. For empirical validation, a recent study by Jones (2008) has shown that in equilibrium (through the income multiplier) these channels can work and potentially enhance the level of technology, which leads to a significant improvement in productivity.

Some recent empirical studies have found a significant role for imported inputs in general, and imported intermediate goods in particular, on productivity. But overall, findings in the literature on this issue are rather mixed. The effects of importing on performance are tested in a variety of ways in the literature. We first look at the overall impact of imported inputs on productivity without considering the type of linkage that exists, vertical or horizontal. Studies of Djankov and Hoekman (2000), Bottasso and Sembenelli (2001), Halpern and Korosi (2001), Pavcnik (2002), Muendler (2004), Schor (2004) and Fernandes (2007) have estimated a positive overall impact of imports on productivity. Some others, for instance, Van Biesebroeck (2003), Muendler (2004), Halpern *et al* (2005), Amity and Konings (2007), Kasahara and Rodrigue (2008), Vogel and Wagner (2010), and Goldberg *et al* (2010), have distinguished vertical linkages from horizontal linkages and shown positive effects of importing.

Where studies have found positive effects of firm imports or declines in input tariffs on productivity, the magnitude of the relationships found has varied considerably. For instance, on the basis of a panel of large Hungarian exporting firms, Halpern *et al* (2015) found that a 1 per cent increase in the share of imports raised firm productivity by 0.22 per cent, for a panel of Hungarian firm for the period 1993-2002. Amity and Konings (2007) estimated a 1 per cent reduction in input tariffs raised the TFP of importing Indonesian firms by 0.12 per cent. Using detailed trade and firm-level data from India, Goldberg *et al* (2010) investigated the relationship between declines in trade costs, imports of intermediate inputs, and domestic firm product scope. They estimated that substantial gains from trade had been achieved through access to new imported inputs. They also found that R&D, output and product source are crucially dependent on the tariff rate on imported inputs. In the Chilean case, Kasahara and Rodrigue (2013) estimated that importing intermediates raised TFP substantially. Colantone and Crinò (2014) showed how new imported inputs affect the introduction of new domestic products in 25 European countries. Their findings indicated that new imported inputs had a strong positive effect on product creation. Others have shown a crucial role for importing and trade liberalisation in the transformation of economies. For instance, Lawrence and Weinstein (1999) found that lower tariffs and higher import volumes were particularly beneficial for Japan during the period 1964 to 1973. Their findings further suggested that in the Japanese case, the salutary impact of imports stems more from their contribution to competition than to intermediate inputs.

Using a different approach, De Loecker *et al* (2012) examine how prices, markups and marginal costs respond to trade liberalisation in India. The

study utilised quantity and price information to disentangle markups from quantity-based productivity, and then computed marginal costs by dividing observed prices by the estimated markups. The study findings indicated that trade liberalisation lowers factory-gate prices, and that declines in tariffs imposed on exports competing with output have the expected pro-competitive effects. Sharma (2014) also shows the important role of imported intermediate inputs on output and TFP in the selected Indian industries.

While discussing the importance of intermediate inputs for economic development, Jones (2008) concluded that they can help in explaining a large income difference across countries. Kasahara and Rodrigue (2008) argued that through adoption and imitation of imported technologies, countries can take advantage of R&D abroad to improve the efficiency of domestic production. Their empirical analysis, using plant-level Chilean manufacturing panel data, clearly suggests that becoming an importer of foreign intermediates improves productivity. Castellani *et al* (2010) found that both exports and imports enhance productivity, but the positive effects of imported inputs are more important than exports, for a sample of Italian firms. Muùls and Pisu (2009) and Altomonte and Bekes (2009) have suggested that the productivity premium of exporting firms is due to the fact that they are also importing.

Focusing on the imports-productivity-export linkage, Melitz (2003) developed a dynamic industry model with heterogeneous firms to examine the intra-industry effects of international trade. The model illustrated how knowledge of trade will induce only the more productive firms to enter into export markets, and will simultaneously force the least productive firms to exit. Extending the Melitz-type model further, Kasahara and Lapham (2013) explained the simultaneous choices of firms regarding the export of final goods and import of intermediate inputs. In their model, firms produce final goods using labour and two types of intermediate inputs, domestically produced or imported. In that framework, firms importing more varieties of intermediate inputs will also have higher productivity. Using similar theoretical mechanisms, Bas and Strauss-Kahn (2014) have shown that importing more varieties of intermediate inputs might affect firm productivity and export performance. More recently, Bas and Strauss-Kahn (2015) have shown that Chinese firms exploit input tariff cuts to access high-quality inputs, in order to upgrade the quality of their exports.

The strand of literature which emphasised important channels through which importing inputs may potentially affect the firm's exporting performance has shown that import liberalisation may promote the competitiveness of domestic firms, as a reduction in input tariffs lessens the cost of imported inputs across all firms (Bas 2012). Furthermore, importing new and more advanced technology inputs enhances productivity, making firms more competitive in export markets (Halpern *et al* 2015). Recently, Lo Turco and Maggioni (2013) for Italian manufacturing and Aristei *et al* (2013) for 27 Eastern European and Central Asian countries have confirmed these channels.

Despite a solid theoretical background and near agreement on the role of imported inputs in the literature, some empirical investigations have shown a minor role for importing. For instance, Van Biesebroeck (2003) found that productivity improvements do not happen through the use of more advanced inputs in Columbia. Similarly, Muendler (2004) reached concluded that there is only a small contribution of foreign materials and investment goods on output for Brazil. The findings of Augier et al (2013) indicated that imported inputs are important. However, the positive effects of these inputs crucially depend on firms' absorptive capacity.

By and large, the balance of findings so far is in favour of a positive effect overall. In the light of strong theoretical but mixed empirical findings, it is both relevant and interesting to explore the issue further, to determine whether the linkage exists in the Indian manufacturing sector.

3. DATA AND TFP ESTIMATION

3.1. Data

In this study we utilise data at the level of two-digit industry groups in the Indian manufacturing sector. The data is gathered from the Prowess database provided by the Center for Monitoring Indian Economy (CMIE). Annual financial statements of firms belonging to eight industry groups, namely Food and Beverages, Textiles, Chemicals, Non-metallic Minerals, Metal and Metal Products, Machinery, Transport Equipment and miscellaneous manufacturing, have been used. Subsequently, firm-level data are transformed into industry-level data by aggregation. Industry-level data are preferred over firm-level data for the analysis in this study, for several reasons: first, in the Prowess database, one of the most important variables for the analysis is not available. Information on compensation to workers is in the database, but data on the number of workers is missing for the majority of firms.

When industry wage rate is used (from the ASI database) to derive the number of workers for each firm (as done in many India based studies, e.g. Sharma, 2014) the derived series is generally observed to be quite inconsistent, because wage rates vary substantially among firms within an industry. This problem severely affects the results of the production function which, in turn, makes TFP results unreliable. This problem is taken care of by using industry-level data, as the industry's average wage works well in this case. Second, several studies have used firm-level data from Prowess, e.g. Goldberg *et al* (2010); De Loecker *et al* (2012) and Sharma (2014), however the main focus of the present study is on the relationship at the industry-level (aggregate -level). Using industry-level data, we are able to consider all firms (more than 15000) in the analysis, while firm-level studies have to use a much smaller sample, because of data related limitations. Finally, the main advantages of a firm-level database in analysis are the use of important information on firms such as entry-exit, competition and pricing. However, because of the very nature of The Prowess database, it does not provide this information.

Considering these issues, we have used firms' aggregated data instead of firm-level data.

Our analysis covers the period from 1994 to 2009. The primary reason for taking 1994 as the initial year is that the Indian economy underwent gradual structural reforms in the early 1990s, and the reforms have subsequently brought about vast changes in the manufacturing sector. Another practical reason is that the data on price indices and deflators for all variables are available only from 1994.

We use gross value added of the industries as the measure of nominal output, which is deflated by industry specific wholesale price indices (WPI) to obtain output in real terms.² The series on real capital stock is constructed using the perpetual inventory capital adjustment method. Specifically, we compute it as:

$$K_t = (1 - \delta)K_{t-1} + I_t \quad (1)$$

where, K is the capital stock, I is deflated gross investment, δ is the rate of depreciation taken at 7 per cent, consistent with similar studies for India (Unel 2003 and Ghosh 2009), and t indicates the year. The initial capital stock equals the net book value of capital stock for the year 1994. Data on other important variables such as exports, imports and R&D have also been extracted from the same database.

3.2. Measuring Total Factor Productivity (TFP)

We start our empirical analysis by estimating TFP for each industry. To this end, we follow a two-stage procedure. In the first stage, a panel of the eight industries is constructed and, following Sharma and Sehgal (2010), our Cobb-Douglas production function to be estimated is:

$$\ln(Q_{it}) = \alpha_0 + \alpha_1 \ln(K_{it}) + \alpha_2 \ln(N_{it}) + \eta_t + \mu_{it} \quad (2)$$

where Q , K , and N are the value added, the capital input and the labour input, respectively, for industry i for period t . α_0 is constant and α_1 and α_2 are the parameters to be estimated. The term η_t represents fixed time effects, while \ln represents log of the variables. The estimation of production functions in a Cobb-Douglas form of a panel data is a challenging task. Griliches and Mairesse (1995) have shown that OLS regressions yield plausible parameter estimates, in line with evidence from factor shares, which is mostly consistent with constant returns to scale. But problems of unobserved heterogeneity and simultaneity - both likely to lead to bias in the OLS results - yield potentially less satisfactory parameter estimates. In other words, observed inputs likely to be correlated with unobserved shock and therefore OLS will yield biased and inconsistent estimates. Initially the GMM estimator is proposed to overcome these problems. The estimator takes first differences to eliminate unob-

served effects and uses lagged instruments to correct the simultaneity. However, Mairesse and Hall (1996) have shown that this method often provides unsatisfactory results in production function estimations. This is primarily because weak instruments could cause large finite-sample biases when using the first-differenced GMM procedure (see Blundell and Bond 1998). Blundell *et al* (2000) showed that use of Sys GMM could dramatically reduce biases, as it incorporates more informative moment conditions that are valid under quite reasonable stationarity restrictions on the initial conditions process. Bond *et al* (2003) and Blundell and Bond (1998) have shown that the additional moment restrictions exploited by the Sys GMM estimator appear to be valid, and they appear to be useful reducing finite-sample biases associated with first-differenced GMM.

It is noteworthy that in the recent related literature, several other potential biases in the production function and their solutions are also discussed. For instance, the estimation of true productivity is confounded by demand shocks and markup, and sometimes these biases are quite significant (see Foster *et al* 2008). Furthermore, De Loecker (2011) has shown that controlling for demand shocks can substantially improve the accuracy of productivity estimates and he addressed the bias arising from unobserved output prices, by using a constant elasticity of substitution (CES) demand system. De Loecker *et al* (2012) have addressed the problem by using prices and quantities of firms' products over time. Moreover, biases stemming from inputs products within multi-product firms, and bias stemming from unobserved input prices, are also highlighted by De Loecker *et al* (2012). In our analysis, we acknowledge that these issues are by and large ignored, because of various reasons including data constraints. Nevertheless, the potential biasness should not be significantly large in our case as we are using industry level data instead of plant or firm data. Furthermore, application of Sys-GMM and sectoral price deflators (in transforming the variables) should also address these biases, to an extent.

Results of the production function are reported in Table 1. Column 1 of the table reports results of the fixed effect estimator, while column 2 reports results of the production function using Sys-GMM. Both results indicate that elasticity of labour and capital are statistically significant and somewhat similar. For TFP computation purposes, we use estimated coefficients of the Sys-GMM estimator.

Utilising the production results of equation 2, we calculate TFP of the sample industries as:

$$\ln(TFP_{it}) = \ln(Q_{it}) - \hat{\alpha}_1 \ln(K_{it}) - \hat{\alpha}_2 \ln(N_{it}) \quad (3)$$

where $\hat{\alpha}_1$ and $\hat{\alpha}_2$ are the estimated parameters of capital and labour, respectively (see column 2 of table 1).

Table 1. Cobb- Douglas Production Function Estimation, 1994-2009
(Dependent Variable: ln(GVA))

Variables	Coefficients (1)	Coefficients (2)
ln (K)	0.44** (0.025)	0.42** (0.021)
ln (N)	0.49** (0.054)	0.43** (0.012)
Const	-.004 (0.12)	-0.011 (0.074)
GVA(-1)		0.22** (0.042)
R ²	0.97	
Estimator	Fixed Effect	Sys-GMM

Notes: Standard errors are in parentheses. ** denotes significant at 5% critical level.

4. EMPIRICAL MODELS AND ECONOMETRIC ISSUES

4.1. Empirical Models

To test the effects of imported inputs, we test two empirical models. The first model is to test the effects of imported inputs on the productivity (TFP) of industries, while the second model examines the effects on export performance of Indian manufacturing industries. These models are as follows:

$$\ln(TFP_{it}) = \alpha_1 + \alpha_2 \ln(\text{Import}_{it}) + \alpha_3 \ln(X_{it}) + e_{it} \quad (4)$$

$$\ln(\text{Export}_{it}) = \beta_1 + \beta_2 \ln(TFP_{it}) + \beta_3 \ln(\text{Import}_{it}) + \beta_4 \ln(X_{it}) + \varepsilon_{it} \quad (5)$$

where TFP, Export and Import are TFP, export intensity (total export/industrial sales) and import intensity (total import/industrial sales), respectively in industry i at year t . X represents two control variables of industries that we consider : R&D intensity (R&D expenditure/ industrial sales) and size (proxied by deflated value of industrial Sales). All variables are converted into logs. Equation 4 tests the role of imported inputs on TFP, after controlling for the effects of size and innovation activities. The second model (equation 5) tests the extent to which imported inputs benefit exporting activities. The model controls for productivity, size and innovative activities.

4.2. Econometrics issue

We focus here on the issue of estimating equations 4 and 5. In the related literature, a number of issues arise relating to application of estimators. These include spurious correlation due to non-stationary data, omitted variables, endogeneity and reverse causality, which may lead to biased estimation of the

coefficients. To attempt to overcome the issue of non-stationarity some researchers, for instance, Hulten and Schwab (1991), used first differences. However, this could be costly as it may remove the long-run characteristics of the variables of interest, with a substantial loss of information. Moreover, it is highly likely that the short-term properties are quite different from the long-term ones.

Some researchers, for example Holtz-Eakin (1994), have used the fixed-effects (FE) estimator for the analysis. The advantage of the FE estimator is that it can handle the issue of omitted variables. FE also somewhat helps in alleviating the adverse consequences of endogeneity bias. Furthermore, to some extent, this estimation method addresses non-stationarity as well because in the 'within' form, deviations from the mean are used in the estimation. Another method which could be useful in the presence of heterogeneity and contemporaneous correlation is Sys-GMM. As discussed in the previous section, this estimator uses extra moment conditions that rely on certain stationarity conditions of the initial observation. When these conditions are satisfied, the resulting Sys-GMM estimator has been shown in Monte Carlo studies by Blundell and Bond (1998) and Blundell *et al* (2000) to have much better finite sample properties, in terms of bias and root mean squared error. Another option is to retain the long-run properties of the series, following Canning and Pedroni (2008), Fedderke and Bogetoft (2009) and Sharma and Sehgal (2010), who apply panel co-integration techniques and establish a long-run relation among panel variables.

After establishing that there is a linear combination between variables that keeps the pooled variables in proportion to one another in the long run, our next step could be to estimate the cointegration equation for both models, using the FMOLS developed by Pedroni (1999, 2001). Pedroni (1999) has shown that with the use of FMOLS on a properly constructed model, the asymptotic distributions for these estimators can be made to be centered around the true value and are likely to be free of nuisance parameters. Furthermore, based on Monte Carlo simulations, it can be shown that, in particular, the t-statistic constructed from the between dimension group means the estimator performs very well for a relatively small sample size. We, therefore, apply the aforementioned methodologies in this study, to check the consistency and robustness of the estimates.

5. EMPIRICAL RESULTS

A preliminary step in our approach involves testing for the stationarity of the series used in equations 4 and 5. This has been done using the cross-sectional Im-Pesaran-Shin (CIPS) panel unit-root test, which is based on the simple averages of the individual cross-sectional augmented Dickey-Fuller statistics. The main advantages of this approach are that it incorporates potential cross-sectional dependence and it does not pool directly the autoregressive parameter in the unit root regression. Thus, it allows for the possibility of heteroge-

neous coefficients of the autoregressive parameters under the alternative hypothesis that the process does not contain a unit root. The results of the unit root test are reported in Table 2. For all individual series the hypothesis of a unit root cannot be rejected at the level form, but it is rejected convincingly in the first difference form.

Table 2: Test for Panel Unit Root Applying Im-Pesaran-Shin (CIPS) W-statistics

<i>Variables</i>	<i>At Level</i>	<i>At 1st Difference</i>
TFP	0.12202	-3.04503**
EXPORT	0.19247	-5.96662**
IMPORT	-0.19036	-7.97863**
RNDINT	1.01247	-2.39198**
Size	-1.22424	-2.73512**

Notes: ** denotes significance at 5%

If the data generating process for the variables is characterised by panel unit roots, it is crucial to test for cointegration in a panel perspective. We apply Pedroni's (1999) test, an extension of the Engle-Granger construction, to test the existing cointegration relationship. Two types of tests have been suggested by Pedroni. The first is based on the 'within dimension' approach, which pools the autoregressive coefficients across different members for the unit root tests on the estimated residuals. The second test is based on the 'between-dimension' approach, which are based on estimators that simply average the individually estimated coefficients for each member. We calculate heterogeneous panel cointegration as well as heterogeneous group mean panel cointegration statistics for equations 4 and 5. These results provide support for a cointegrating relationship among variables in both models.³

As explained earlier, after establishing a linear combination between variables that keeps the pooled variables in proportion to one another in the long run, our next step is to estimate the cointegration equation for both models. Because OLS estimators are biased and inconsistent when applied to cointegrated panels, we utilise the 'group-mean' panel FMOLS estimator.⁴ The estimator corrects the standard pooled OLS for serial correlation and endogeneity of regressors that are normally present in long-run relationship. It is noteworthy that in this study we are not interested in reverse causality, therefore we restrict our focus to an estimation of equations 4 and 5.

Results of the estimation of equation 4 are reported in Table 3. Overall, the results suggest that imported inputs are a determinant of TFP, as the elasticity is estimated to be around 0.07, which indicates that a 1 per cent increase in imported inputs leads to a 0.07 per cent increase in the TFP of manufacturing firms in India. However, the impact varies greatly across industries. The TFP of Metal and Metal products, Food and Beverage,

Machinery and Textile industries are heavily dependent on imports, while in other industries the effects are either minimal or statistically insignificant. The result regarding Metal and Metal products is quite large (0.23), which makes sense as these firms, including from iron and steel, are heavily dependent on quality imported inputs. Surprisingly, however, for Transport equipment (which includes Automobiles) and Chemicals (which includes Drug and Pharmaceuticals) the coefficients are not statistically significant. Bas and Strauss-Kahn (2014) have estimated quite similar results for French industries. Specifically, they have found 0.068 per cent to 0.096 per cent effects on TFP when imported inputs increased by 1 per cent, while in the Indian case, we have estimated it to be 0.07 per cent.

Another important result concerns R&D intensity, with in-house R&D activities not playing any significant role in the productivity performance of Indian manufacturing. This is in line with the earlier findings of Sharma and Mishra (2011) and Sharma (2012) for Indian manufacturing.

Table 3: FMOLS Result: Effects of Imported Intermediary Inputs on TFP, 1994-2009

<i>Industry</i>	<i>Import-Raw</i>	<i>Output</i>	<i>RNDINT</i>
Chemical	-0.004803 (-0.138)	0.740172 (1.1205)	0.067880 (1.1243)
Food and Beverage	0.193015** (2.158)	-3.454734 (-0.7271)	0.058214 (1.079)
Machinery	0.123470 (0.841)	-0.407117 (-0.3123)	0.002546 (0.0311)
Metal & metal products	0.2298** (5.4005)	1.937868** (3.7422)	-0.007070 (-0.2679)
Non metallic mineral products	0.007168 (-0.2679)	4.463531** (2.1536)	-0.033993 (-1.3653)
Textile	0.090379** (1.957)	1.144505** (2.8062)	0.002404 (0.2637)
Transport equipment	-0.035368 (-1.1844)	0.410490** (2.1724)	0.023554 (0.2637)
Miscellaneous manufacturing	0.135476 (1.5207)	1.649393 (1.1999)	0.067323 (1.1162)
Overall	0.069806** (2.3684)	0.810513** (4.297)	0.022607 (1.3714)

Notes:

1. ** and * denote significant at 5% and 10% critical level respectively.
2. t-statistics in parentheses.

The previous empirical literature has mainly tested import-export cost complementarities and the export-enhancing effect of imports, which work through productivity gains (e.g. Bas and Strauss-Khan 2011; Kasahara and Lapham 2013). In the next stage, we attempt to test the direct effects of

importing on exporting performance. To this end, we have estimated Equation 5 and report results in Table 4. Results suggest the import elasticity is quite large (0.43), thus a 1 per cent increase in imports leads to 0.43 per cent growth in exports. This link is especially strong for exports in the Chemical, Machinery and Transport equipment industries. This is indeed an important finding for policy perspectives. The results also indicate that although R&D is not linked with the productivity of industries, it has an important role in the export performance of these industries.

TFP is also estimated to have a significant and sizable association with export performance. This supports the self-selection hypothesis, which explains the self-selection of more productive firms into the export market. The magnitude of the estimated relationships are relatively large when compared with the findings of previous studies for other countries, for instance, Lo Turco and Maggioni (2013) for Italy, which has estimated a much lower coefficient. Previous studies on India, for instance Sharma and Mishra (2011), have shown a minor effect of exporting on productivity but a noticeable effect of reverse causality. Thus one can conclude exporting and importing share complementarity, with both affecting the productivity of firms significantly.

Table 4: FMOLS Result: Effects of Imported Inputs on Exports, 1994-2009

<i>Industry</i>	<i>Import</i>	<i>Size</i>	<i>RNDINT</i>	<i>TFP</i>
Chemical	0.58024** (2.528)	0.149886 (0.832)	0.796764** (3.272)	-0.974615 (-1.096)
Food and Beverage	-0.032527 (-0.919)	-0.101435 (-1.146)	0.022434 (0.824)	0.597837** (2.279)
Machinery	1.38057** (6.602)	0.20570** (2.299)	0.426776** (3.918)	0.703451 (1.362)
Metal & metal products	-0.09956 (-0.374)	0.753364** (2.139)	0.096431 (0.931)	0.780521 (0.567)
Non metallic mineral products	0.55358** (5.828)	-0.093055 (-0.582)	0.013441 (0.518)	2.867779** (4.496)
Textile	-0.204325 (-1.797)	0.317212** (5.181)	0.006157 (0.313)	0.300186 (0.418)
Transport equipment	0.798121** (5.828)	0.271168** (2.518)	0.059928 (0.627)	-2.712648 (-1.676)
Miscellaneous manufacturing	0.492151 (1.091)	-0.394143 (-0.689)	-0.050884 (-0.331)	0.166357 (0.103)
Overall	0.433532** (6.642)	0.138587 ** (3.731)	0.171381** (3.561)	0.216108** (2.282)

Notes:

1. ** and * denote significant at 5% and 10% critical level respectively.
2. t-statistics in parentheses.

To test the robustness of the FMOLS results, we re-estimated Equations 4 and 5 using OLS fixed effects and Sys-GMM. The results are reported in Table 5. Columns 1 and 3 report the results in which TFP is the dependent variable and the model is estimated using fixed effect and Sys-GMM, respectively. The estimated coefficients of imported raw materials are 0.077 and 0.054 which is quite close to the FMOLS results. Furthermore, findings on R&D are again found to be insignificant. Focusing on results in column 2 of Table 5, fixed effect estimates indicate that imported inputs effects are 0.31 per cent. However, Sys-GMM results provide a moderate size (0.092) of effects on export performance. Importantly, the Sys-GMM results also confirm positive effects for R&D efforts on export performance. Overall, these results endorse our FMOLS based estimated results.

Table 5: Robustness Check: Effects of Imported Inputs on TFP and Export, 1994-2009

<i>Industry</i>	<i>Dependent Variable-TFP (1)</i>	<i>Dependent Variable- Export (2)</i>	<i>Dependent Variable-TFP (3)</i>	<i>Dependent Variable- Export (4)</i>
Import	0.0774007** (2.69)	0.3118253** (4.19)	0.0549159** (2.83)	0.0927318** (2.06)
Size	0.6753878** (31.96)	-0.3289995** (-1.99)	0.4890057** (15.37)	-0.1070502 (-1.34)
RNDINT	-0.0203007 (-1.66)	0.0230971 (0.75)	0.0022485 (0.27)	0.0378972** (2.23)
TFP		1.047218 ** (4.52)		0.192286 (1.63)
TFP(-1)			0.3468024** (7.76)	0.8180675 (18.15)
Export(-1)				
Constant.	-0.524892** (-7.10)	-0.2606437 (-1.18)		92.36612 (0.6141)
Sargan χ^2 (P-value)			262.3476 (0.00)	
R ²	0.9214	0.6025		
Estimator	Fixed	Fixed	Sys-GMM	Sys-GMM

Notes:
1. ** denotes significant at 5% critical level.
2. t-statistics in parentheses.
3. Sargan is the Sargan (1958) test of over-identifying restrictions

6. CONCLUSION AND POLICY SUGGESTIONS

There is a voluminous empirical literature available on industrial performance and exports, however, much less consideration has been given to the import behaviour and firm or industry characteristics. Even fewer analyses consider the linkage between import and export activities. This is unfair, given the

strong association between importing and exporting and the key role of imports in the world economy. In order to fill these gaps, in this study we have tested the effects of import intermediate inputs on productivity. We have also analysed the role of imported inputs on the export performance of manufacturing industries.

Our results indicate that imported intermediate goods are crucial determinants of TFP. However, it is noteworthy the impact varies greatly across industries. The TFP of Metal and Metal products, Food and Beverage, Machinery and Textile industries are heavily dependent on imports, while in other industries the effects are minimal. Furthermore, the results regarding R&D intensity suggest that in-house R&D activities do not play a significant role in the productivity performance of Indian manufacturing. Nevertheless, in some industries, R&D intensity has a significant impact on export performance. This may be an indication that R&D activities mainly focus on export gain.

Our results also confirm that imported inputs lead to a substantial growth in exports. Exports by the Chemical, Machinery and Transport equipment industries in particular are highly dependent on imported inputs. This is indeed an important finding from a policy perspective. The results also indicate that although R&D is not linked significantly with the productivity of industries, it has an important role in the export performance of these industries. TFP is also estimated to be significantly related to export performance. This supports the self-selection hypothesis, which explains the self-selection of more productive firms into export markets. These results indicate that imported inputs are crucial for both productivity and exporting. Therefore, it seems that imported inputs provide competitiveness to firms in terms of quality as well as cost, as it affects exports directly, as well as indirectly through productivity channels.

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ENDNOTES

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2. We use gross value added as a measure of output in the production function for computing TFP. There are many advantages of using gross value added over output. First, it makes it possible to compare between firms that use different raw materials. Second, if gross output is used as a measure of output, it adds the necessity of including raw materials, which may obscure the role of labour and capital in productivity growth (Hossain and Karunaratne 2004; Kumar, 2006).

3. These results are not reported because of space constraints. They will be provided on request to the author.
4. We have applied 'group-mean FMOLS', because we have a small sample for the analysis. Pedroni (2000, 2001) has shown that the 'group-FMOLS' has relatively lower small sample distortions and more flexibility in terms of hypothesis testing than the other three versions of FMOLS (see also Basher and Mohsin 2004).
5. The reason behind this hypothesis is the presence of sunk costs when entering and selling goods in foreign markets. See Sharma and Mishra (2011) for details.

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How important are foreign and domestic investments, exports and human capital for Greece's economic growth?

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ABSTRACT

This study investigates empirically the causal relationship between economic growth and its determinants (foreign direct investment, domestic investment, exports, human capital) in Greece over the period 1970-2012. It uses time series analysis and estimates the effect of these determinants on economic growth, by applying a modification of Mankiw, Romer and Weil (1992) model. The empirical analysis reveals that there is evidence of unidirectional long-run and short-run Granger causality running from foreign direct and domestic investments, exports and human capital to economic growth; and that there is a positive effect, in the long-run, of all determinants on economic growth. The contribution size of these economic variables, especially of foreign direct investment, is probably not adequate and sufficient to bring the Greek economy back to growth. Greece needs to implement many important structural reforms which will enhance the contribution of these determinants to economic growth.

1. INTRODUCTION

ECONOMIC GROWTH AND ITS DETERMINANTS have been a major and extensive area of study and research over the past few decades, especially in developing countries. According to the macroeconomic literature, as reflected after World War II, there are two main approaches that explain the sources of economic growth: the neo-classical approach, based on Solow's growth model (1956), and the new or endogenous approach, based on growth models developed by Lucas (1988), Romer (1986, 1990), Grossman and Helpman (1991), Aghion and Howitt (1992) and others (Sianesi and Van Reenen 2003).

Later, the augmented neo-classical growth model of Mankiw *et al* (1992), extended the Solow model. The neo-classical growth model emphasises the importance of investment in physical capital, while endogenous growth models focus on the key role of human capital, research and development (R&D)

and innovation. The basic underlying assumption of the neo-classical growth model is that diminishing returns on capital exist in the production process, while endogenous growth models are based on the assumption that the production function exhibits increasing returns to scale. Despite these differences, both economic models and theories converge in the estimation that foreign direct investment (FDI), domestic investment, exports and human capital are key determinants of economic growth.

There are significant interactions and strong relationships between FDI, domestic investment, exports, human capital and economic growth. More specifically, FDI inflows can play a vital role in host countries, because it increases the supply of funds for domestic investment, through a knowledge diffusion effect often referred as externalities or efficiency spillovers, from the more advanced technology and management practices used by foreign firms (Findlay 1978). FDI has two potential effects on domestic investment, by competing in product and financial markets. Thus FDI can increase growth in two ways: first, it enhances total investment by attracting higher levels of domestic investment; and second, through the interaction of more advanced technology with the host's human capital, FDI may be more productive than domestic investment (Ewe-Ghee, 2001). Furthermore, FDI inflows not only increase the export capacity of the host country, but also induce new job vacancies (Stamatiou and Dritsakis 2013).

The adoption and application of new technologies require the accumulation of a substantial amount of human capital in the host economy. This means that human capital, especially those with higher education qualifications in the host economy, acts as a limit to the absorptive capability of a developing country (Borensztein *et al* 1998). Human capital determines the economy's ability to create new ideas and adapt old ones. It also spurs economic growth by attracting FDI used for capital intensive production processes (Ogunade 2011). FDI and human capital can complement each other in the process of productivity growth: FDI creates potential spillovers of knowledge to the local labour force while, at the same time, the host country's level of human capital determines how much FDI it can attract and whether local firms are able to absorb the potential spillover benefits (Adefabi 2011). Education, as an indicator of human capital, is one of the main factors that influences the development of trade and is one of the building blocks of productivity. A workforce with higher levels of education will have potential for change and for being innovative. Human capital and foreign trade are complementary factors; they interact with each other and work together to strengthen economic growth and development (Levin and Raut 1997).

The motivation for this study comes from the necessity to identify the relationship between economic growth and its determinants in Greece. Greece experienced political stability during the examined period 1970-2012, with the exception of the period 1970-1974 due to the dictatorship; and the period 2010-2012 as a result of accession to the European support mechanism and

the signature of the memorandum. During the examined time period, two major milestones influenced the development of the Greek economy, namely the accession of the country to the European Community (EC) in 1981, and accession to Economic and Monetary Union (EMU) in 2001. As a result, Greece became a member of the hard core of the European Union, it transformed into a developed country, and its economy was based mainly on the tertiary sector. During this transition period, some structural reforms and adjustments were implemented, more or less successfully. Generally, however, the Greek economy passed into the 21st century facing a number of unsolved problems, mainly high temporal twin debts and deficits.

For many years the Greek government's strategy was not effective enough in attracting investment, especially FDI. The main obstacles were high business taxes and excessive bureaucracy. These issues are closely related with the determinants of economic growth that will be examined in this paper. In 2009, the global financial and economic crisis, which started in 2007, triggered the diachronically underlying structural and functional deficiencies of the Greek economy, its public sector and its administration. As a result, in 2010 Greece entered the European support mechanism (comprised of the European Commission, the European Central Bank and the International Monetary Fund), and thereafter an austerity-frontloaded fiscal consolidation process was followed and difficult structural reforms implemented. Today, Greece remains under the strict supervision of the three institutions, has signed a new, third, bailout programme and faces prolonged recession and high unemployment.

The purpose of this study is to investigate empirically the long-run and short-run causal relationships between FDI, domestic investment, exports, human capital and economic growth, and to estimate the effect of each variable on economic growth in Greece over the period 1970-2012. This paper attempts to provide new evidence on this issue from the perspective of a single country, rather than a cross-country viewpoint. To the best of our knowledge, this is the first study which investigates in the same empirical economic model the impact of FDI, domestic investment, exports and human capital on economic growth in a single European country that belongs in the periphery of the European Union.

The rest of the paper is organised as follows. Section 2 reviews the empirical literature on the relationships between domestic and foreign investment, exports, higher education and economic growth. Section 3 presents the empirical analysis, discusses the methodology, explains sources and data and reports the empirical results based on econometric analysis and discussion. Section 4 presents the concluding remarks.

2. REVIEW OF EMPIRICAL STUDIES

The current literature review involves studies which have dealt with the effect of FDI, domestic investment, exports and human capital in economic growth,

either for each variable separately or for some of them together, or even for all variables simultaneously.

FDI and economic growth

Many studies have been conducted in the fields of FDI and economic growth. Some of them are reviewed below. De Gregorio (1992) found a positive effect on growth for twelve Latin American countries over the period 1950-1985. Chakraborty and Basu (2002) suggested that GDP in India is not affected by FDI, and the causality runs from GDP to FDI. Chowdhury and Mavrotas (2003), examining the casual relationship between FDI and economic growth for Chile, Malaysia and Thailand covering the period 1969-2000, concluded that GDP affects FDI in the case of Chile, while for both Malaysia and Thailand, there is a strong evidence of a bi-directional causality between the two variables. Apergis *et al* (2004) investigated the causal relationship between FDI and growth for a set of transition economies. Their results indicated bi-directional causality between the two variables. In the case of East European countries, similar results were found by Bhandari *et al* (2007). The main conclusion is that an increase in the stock of domestic capital and inflows of FDI positively affect economic growth.

Exports and economic growth

Alici and Ucal (2003) found only unidirectional causality from exports to output for Turkey, using seasonally unadjusted quarterly data for the period 1987-2002. Shirazi and Manap (2004) found strong evidence of unidirectional causality from exports to economic growth in Pakistan over the period 1960-2003. Jordaan and Eita (2007) concluded that export-led growth strategy has had positive impact on economic growth in Namibia over the period 1970-2005.

Human capital and economic growth

The impact of human capital and, more specifically, the impact of higher education on economic growth, has been examined extensively in the economic literature. Barro and Sala-i-Martin (1995) conducted a cross-sectional study of 111 countries and concluded that an increase of 0.09 years in higher education raises the annual growth rate by 0.5 percentage points. They also found an interaction between initial GDP and human capital, which means that countries that lag behind tend to grow faster if they observe higher levels of human capital.

De Meulemeester and Rochat (1995) found a significant causal link from higher education to economic growth in Japan, the United Kingdom, France and Sweden but lack of significant effects in Italy and Australia. Simoes (2004), by using average years of schooling for estimating the impact of educational levels on economic growth in a sample of 23 OECD countries, found a positive and significant relationship between higher education and growth.

Loening (2005) investigated the impact of human capital on economic growth in Guatemala over the period 1951-2002. The results showed that the share of the labour force with higher education has positive and significant effects on growth. Bloom et al (2006) concluded that increasing the stock of tertiary education by one year could raise the output of Sub-Saharan African countries by 0.12 percentage points per year. Pegkas and Tsamadias (2014) investigated the case of Greece over the period 1960-2009 and found that there is a positive long-run cointegrating relationship between higher education and economic growth; and unidirectional long-run and short-run Granger causality running from higher education to economic growth.

FDI, exports and economic growth

Several studies have investigated the impact of FDI and exports on economic growth. Liu et al (2002) found bidirectional causality between each pair of GDP, exports, and FDI for China, using seasonally adjusted quarterly data over the period 1981-1997. Ahmad *et al* (2004) found unidirectional causality from exports and FDI to GDP for Pakistan, using annual data capturing the period 1972-2001. Dritsaki *et al* (2004) investigated the causal relationship between FDI, exports and economic growth for Greece over the period of 1960-2002. Their findings showed that there is a long run relationship between these variables, bidirectional causality between GDP and exports, and unidirectional causalities running from FDI to exports and GDP.

Hsiao and Hsiao (2006) set up a panel vector autoregressive model for a set of countries (China, Korea, Taiwan, Hong Kong, Singapore, Malaysia, Philippines, and Thailand). Their results revealed that FDI has unidirectional effects on GDP directly; and also through exports indirectly, while bidirectional causality between exports and GDP for the group also exists. Yao (2006) investigated the effect of exports and FDI on economic growth, using a panel data set encompassing 28 Chinese provinces over the period 1978-2000. The results of the study showed that both exports and FDI have a strong and positive effect on economic growth. Stamatiou and Dritsakis (2013) investigated the relationship between exports, FDI and economic growth in five eurozone countries (Greece, Portugal, Ireland, Spain, and Italy) for the period 1970-2011. The results revealed that there is bidirectional causality between exports and economic growth, while there is no causality between economic growth and FDI neither between FDI and exports.

FDI, domestic investment, human capital and economic growth

Other studies have investigated the impact of foreign and domestic investment and human capital on economic growth. Blomstrom *et al* (1994), for a combination of 78 developing and 23 developed countries, found that over the period 1960-1985, FDI has a significant positive influence on economic growth, but the influence seems to be confined to higher-income developing countries. The authors also found that domestic investment and human capital have a

positive effect on economic growth. Borensztein *et al* (1998) for 69 developing countries over the period 1970-1989, found that while FDI is an important vehicle for the transfer of technology and a positive contributor to economic growth, its impact is greater the higher the level of human capital in the host economy. Their results indicated that for host countries with very low levels of human capital, the direct effect of FDI on growth is negative, otherwise it is positive. They also found that FDI is more productive than domestic investment.

FDI, domestic investment, exports, human capital and economic growth

To the best of our knowledge there are very few studies which have taken into consideration these four variables together. Shahbaz and Rahman (2010) investigated the relationship between FDI, public investment, human capital and trade openness with economic growth in Pakistan over the period 1971-2008. Their results indicated that all variables have positive effects on economic growth. Anwar and Nguyen (2011), in their study for 61 provinces of Vietnam over the period 1996-2005, found that FDI, domestic investment, exports and human capital have positive effects on economic growth.

The basic findings from the empirical literature can be summarised as follows. Almost half of the studies have investigated the case of a single country, using time series data in their econometric analysis. The rest of the studies have investigated the case of many countries, using cross sectional data or panel data. The majority of the studies does not use a particular theoretical growth model, but use the VAR methodology to find long-run and short-run relationships between the variables, based on a simple linear theoretical model. A few studies have followed a specific growth model (for instance, the study of Pegkas and Tsamadias (2014) has used the Mankiw *et al* (1992) model).

The majority of the studies that have investigated a sample of many developed countries have found that there is positive long-run relationship, with causality stemming from domestic investment, FDI and human capital to economic growth; and with bidirectional causality between exports and economic growth. The majority of the studies that have investigated a sample of less developed countries showed that there is positive long-run relationship, and mainly bidirectional causality, between FDI and economic growth. The majority of the studies that have investigated one developed country have found a positive long-run relationship, with causality stemming from domestic investments and human capital to economic growth, and bidirectional causality between exports and economic growth and between FDI and economic growth. The results of our study are consistent with the results of these studies. Finally, the majority of the studies that have investigated one less developed country showed that there is positive long-term relationship and, mainly, a unidirectional causality, from FDI and exports to economic growth. All the results mentioned above hold regardless to the proxy of the human capital that all studies have used.

The results of our study are in line with the studies of De Meulemeester and Rochat (1995) and Pegkas and Tsamadias (2014), who have used enroll-

ment rates in higher education as a proxy of human capital. In general, the empirical literature suggests that there are interactions between domestic investments, FDI, exports and human capital and positive relation among these variables and economic growth. The level of economic growth in every country plays an important role in this. That is because, for developed economies, the interactions will be more powerful. That holds because most developed countries have a more highly-qualified and productive human capital stock; and they have the expertise to make important domestic investments to allow for more spillover effects from the foreign direct investments. In this way these countries can increase exports and thus the economy is growing.

3. EMPIRICAL ANALYSIS

This section presents the methodology, the data, the sources and the econometric analysis (stationarity properties of the data, cointegration test, vector error correction model, Granger causality test, impulse response functions and variance decomposition analysis). Finally, the section presents the results and a discussion of the findings.

3.1 Methodology and model

The neo-classical model, originally proposed by Solow (1956), assumes an aggregate production function, with arguments of effective labour and physical capital. Technological progress, population growth and capital depreciation take place at constant, exogenous rates. The empirical analysis of this paper uses the methodology of the Solow model, extended with human capital, as in Mankiw *et al* (1992), whereby investment is comprised of its domestic and foreign direct components, and the production function is expanded by adding exports as an extra variable. Regardless of criticisms, neo-classical growth theory has dominated economic thought because it can explain much of the economic growth in the world and because it is mathematically elegant.

In order to capture the explicit role of human capital in determining economic growth, Mankiw *et al* (1992) augmented the Solow model by including human capital as well as physical capital. They concluded that an augmented Solow model with both human and physical capital provides an excellent explanation for economic growth. The simple theoretical framework provided by Mankiw *et al* (1992) has been very influential and much cited in the time series and cross-country growth regression literature. The generalised Mankiw *et al* (1992)-type framework that we have developed here, by using the variables domestic investments, foreign direct investments, exports and human capital, has the potential to prove helpful in describing economic growth in Greece. Also, the availability of data for Greece fits better the Mankiw *et al* (1992) model.

Mankiw *et al* (1992), assume a Cobb-Douglas production function with constant returns to scale and decreasing returns on physical and human capital. We assume a production function of the following form:

$$Q = K_d^\alpha K_f^\beta H^\gamma E^\delta (AL)^{1-\alpha-\beta-\gamma-\delta} \quad (1)$$

where Q stands for aggregate output, K_d is domestic investment in physical capital, K_f is FDI in physical capital, H is human capital, E represents exports, A is a technical efficiency index and L stands for labour. We assume that L and A grow at constant and exogenous rates n and g , respectively. The exponents α , β , γ and δ measure the elasticity of output to the respective inputs.

Considering decreasing returns to scale, that is: $\alpha + \beta + \gamma + \delta < 1$, we transform equation (1) into a linear equation on income per worker and get the following function:

$$\ln q_t = a_0 + a_1 \ln k_{dt} + a_2 \ln k_{ft} + a_3 \ln(n + g + \delta)_t + a_4 \ln h_t + a_5 \ln(ex_t) + \varepsilon_t \quad (2)$$

where q_t refers to GDP per worker during each period, k_{dt} is domestic investment as a percentage of GDP taking place in the economy, k_{ft} is FDI, n , g and δ , are the exogenous growth rates of labour, technology and depreciation rate of capital respectively, h_t is the gross percentage of the people enrolled in higher education, ex_t is total exports as percentage of GDP, and ε_t is the error term.

3.2 Sources and data

Data on Gross Domestic Product (GDP), total domestic (including private and public) investment, exports and employment are annual and obtained from the AMECO database (2014), while data on FDI were taken from the World Bank database (2014). GDP per worker ($\ln q_t$) is measured at 2005 constant prices, total domestic investment ($\ln k_{dt}$) is the gross capital formation as percentage of GDP at 2005 constant prices for the total economy, foreign investment ($\ln k_{ft}$) is FDI as percentage of GDP at 2005 constant prices for the total economy, exports ($\ln ex_t$) is the total exports as percentage of GDP at 2005 constant prices for the total economy and labour force ($\ln n_t$) includes all persons classified as employees and self-employed for the whole economy. For the variable ($\ln n + g + \delta$), only the growth rate of the labour force is used. It should be noted that according to the Mankiw *et al* (1992) model, the growth rates of technology and depreciation rate of capital remain constant for all countries, assuming that $g + \delta = 0.05$, considering that technology (and therefore its rate, g) is a public good available to all countries. These assumptions we apply to Greece. The proxy of human capital used in this study is higher ($\ln h_t$) enrolment rates, including enrolment rates in the higher education system. Data for constructing a human capital proxy are taken from the Hellenic Statistical Authority (HSA) database (2014). The estimation of this variable is achieved using the following function (World Bank 2014):

$$GHER^t = \frac{E^t}{P^t} * 100 \quad (3)$$

where $GHER^t$ = Gross Higher Enrolment Ratio in school year t, E^t = Enrolment for higher level of education in school year t (age 18-22), P^t = Population in age-group which officially corresponds to higher level of education in school year t (age 18-22).

In Greece, over the period 1970-2012, a significant GDP increase is observed. Specifically, positive growth rates were achieved, but especially in the 1970s and the period 1995-2007. The average annual growth rate of GDP, over the whole period, was approximately 2.03 per cent in real terms, but there were periods of very high growth rates and periods of stagnation. In particular, the average annual growth rate of GDP was approximately 5.15 per cent and 0.78 per cent in the 1970s and 1980s respectively, 1.91 per cent in the 1990s, 3.04 per cent in the 2000s and -6.14 per cent during the period 2010-2012. Furthermore, over this period, Greek GDP per worker increased by an average of 1.60 per cent, with the highest growth rate during the 1970s and the lowest (negative) rate during the 1980s and the period 2010-2012.

Table 1: GDP, domestic and foreign investment, exports and higher education

Years	GDP per worker (2005=base year)	Domestic investment (2005=base year) as percentage of GDP	Foreign direct investment (2005=base year) as percentage of GDP	Exports (2005 = base year) as percentage of GDP	Higher enrollment rates
1970	21.697	32.369	0.399	5.632	14.770
2012	41.341	13.576	0.667	25.042	66.027
1970 - 2012	33.178	22.084	0.818	16.316	33.894
1970 - 1979	27.902	29.990	0.604	8.798	19.108
1980 - 1989	30.054	18.887	1.030	14.019	26.435
1990 - 1999	32.406	18.722	0.835	17.369	28.728
2000 - 2009	40.707	22.646	0.928	22.841	52.342
2010 - 2012	40.981	15.722	0.409	23.781	63.775

Years	GDP per worker average growth rate	Domestic investment as percentage of GDP average growth rate	Foreign direct investment as percentage of GDP average growth rate	Exports as percentage of GDP average growth rate	Higher enrollment rates average growth rate
1970 - 2012	1.60	-1.63	82.88	3.94	3.83
1970 - 1979	4.50	-3.84	108.97	9.11	4.91
1980 - 1989	-0.25	-1.58	-0.49	2.49	3.55
1990 - 1999	1.22	2.21	-7.61	4.49	0.19
2000 - 2009	1.85	-1.51	247.64	-0.85	6.69
2010 - 2012	-0.45	-8.38	34.95	7.39	3.98

Source: AMECO database and Hellenic Statistical Authority (EL.STAT.) All data are obtained from Authors' calculations

The average domestic capital investment rate was 22 per cent of GDP for the entire examined time period. The average annual growth rate of domestic capital investment over the whole period was approximately -1.63 per cent in real terms. Indeed, this growth rate was negative for all years, except for the period 1990-1999. Foreign direct investment averaged 0.82 per cent of GDP for the entire examined time period, but FDI growth averaged about 82.88 per cent per year over the period 1970-2012. The highest FDI growth rate occurred during the 2000s and the lowest (negative) during the 1990s.

Exports averaged 16.31 per cent of GDP over the entire time period, during which Greek exports experienced an average annual increase of 3.94 per cent; with the highest growth rate seen during the 1970s and the lowest (negative) rate during the 2000s. During the examined time period, and mainly in the last three decades, the higher education system has expanded rapidly. The enrolment rate in higher education has increased from almost 15 per cent of adults aged 18-22 in 1970, to 66 per cent in 2012, exhibiting an average annual growth rate of 3.83 per cent (Table 1). However, when this time period is split into five 10-year periods, it becomes obvious that this increase shows no uniformity. During the 2000s we observe the highest growth rate of enrolled students, while in the 1990s the lowest. Furthermore, by examining such a long time period (43 years), variable bias is limited by allowing enough time for the effect of human capital on economic growth to take place.

3.3 Econometric analysis

This section focuses on the effect of foreign and domestic investment in physical capital, exports and higher education on economic growth, using a VAR methodology. First, the order of integration is checked and then cointegration tests are used to examine the existence of long-run relationships between the variables. Second, Granger (1986, 1988) causality tests, based on a vector error correction approach, are applied. Third, the impulse response functions and variance decomposition are plotted and calculated, to investigate the dynamic relationships between the variables of the models.

3.3.1 Stationarity Test

Initially, the stationarity of the variables (GDP per worker, domestic investment, FDI, exports and higher education) is examined, using the Augmented Dickey-Fuller (ADF) (1981), the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) (1992) and the Perron (1997) structural break tests. We test for the presence of unit roots and identify the order of integration for each variable in levels and first differences. The variables are specified including intercept and intercept and trend. The optimal lag length of the ADF regressions is determined by the Akaike (1974) criterion. KPSS statistics are obtained by the Bartlett Kernel and the automatic bandwidth parameter approach as suggested by Newey and West (1994). For the Perron structural break test, the maximum lag length is specified by the user to be equal to 4. For the ADF test the null hypothesis is

non-stationarity, for the KPSS test is stationarity and for the Perron test is non-stationarity with a structural break. Unit root test results are provided in Table 2.

Table 2: Results of unit root tests

Variables (in levels and first differences)	ADF test		KPSS test		Perron test	
	With inter- cept in equation	With inter- cept and trend in equation	With inter- cept in equation	With inter- cept and trend in equa- tion	With inter- cept in equation	With inter- cept and trend in equation
lnq	-1.5712	-2.6330	0.7652*	0.0991	-4.0422	-3.8936
Δ lnq	-5.2348*	-5.2276*	0.2006	0.1250	-5.9530*	-6.1271**
lnk _d	-1.1563	-1.4914	0.4721**	0.2040**	-3.5813	-2.1498
Δ lnk _d	-6.1901*	-6.1082*	0.1532	0.1580**	-6.6257*	-6.7854*
lnk _f	-2.3881	-2.2924	0.7601*	0.2427*	-7.2662*	-6.9627*
Δ lnk _f	-8.6114*	-8.6357*	0.0526	0.0430	-12.559*	-12.814*
lnex	-2.6898	-3.0842	0.7961*	0.1620**	-3.9641	-3.4861
Δ lnex	-5.4737*	-5.6908*	0.3079	0.0991	-6.0976*	-6.0316**
lnh	-1.0309	-2.4864	0.7552*	0.1491**	-4.3147	-4.4444
Δ lnh	-3.6284*	-3.5726**	0.0794	0.0768	-4.4724	-4.4143
ln(n+g+ δ)	0.3749*	0.7352*	0.2214	0.1210	-2.8878	-6.5787*
Δ ln(n+g+ δ)	-9.2081*	-9.6737*	0.3221	0.1348	-10.6156*	-11.611*

Notes: *, ** indicates the rejection of the null hypothesis of non stationarity for (ADF) and Perron tests or stationarity (KPSS) at 1% and 5% level of significance respectively. For ADF test MacKinnon (1996) critical values have been used for rejection of hypothesis of a unit root. For KPSS test KPSS (1992, Table 1) critical values have been used for rejection of hypothesis of stationarity. For structural break test critical values are those reported in Perron (1989).

With the variables specific in levels, the results indicate that, with a few exceptions, we cannot reject the null hypothesis of non stationarity at 5 per cent. The cases that the variables provide mixed results are for GDP, the KPSS test in the case with intercept and trend, and for the variable of FDI, the Perron test in the cases with intercept and with intercept and trend. For the variable of $n+g+\delta$, all tests show stationarity except for the Perron test in the case with intercept. With the variables specified in first differences the results reveal that, with a few exceptions, we can reject the null hypothesis of non stationarity at 5 per cent. More specifically, for two variables the results are mixed. For the variable of domestic investment, the KPSS test in the case with intercept and trend shows non stationarity and, for the variable of human capital, the Perron test shows non stationarity in the cases with intercept and with intercept and trend. From the above stationarity tests analysis we con-

clude that the combined results show that all variables are I(1) except the variable of $n+g+\delta$, which is I(0).

3.3.2 Cointegration test

Stationarity tests show that all variables which are non-stationary in levels become stationary in first differences: they are integrated of order (1). Thus there is the possibility that the variables output per worker, foreign and domestic investment in physical capital, exports and higher education are cointegrated. The variable $(n+g+\delta)$ is taken as exogenous in the model. In order to account for other influences on GDP per worker, three dummy variables are added to the VAR model. The first dummy variable is for 1974, when the international oil crisis took place and GDP experienced a significant fall. The second dummy variable is for 2002, when Greece as a full member of eurozone adopted the single currency and was among the first wave of countries which launched euro banknotes and coins on 1 January 2002. The third dummy variable is for 2010, when Greece entered a trilateral financial support mechanism led by the European Commission, the European Central Bank and the International Monetary Fund.

To determine the lag length of the VAR, three versions of the system are estimated initially: a four, a three and a two-lag version. Then, taking into account information and criteria, we identify two lags as the optimal lag length. The cointegration test was conducted using the reduced rank procedure developed by Johansen (1988) and Johansen and Juselius (1990). The Johansen multivariate cointegration approach is used to examine the long-run relationship between the variables. The estimation procedure assumes an intercept and trend in the VAR estimation. This cointegration method recommends two statistics to check the long-run relationship: the Trace and the maximum Eigenvalue tests. The null hypothesis in the Trace and maximum Eigenvalue tests is that there is no cointegrating vector. Comparing³ the Trace and the maximum Eigenvalue cointegration tests and taking into account the results from Table 3, we conclude that the null hypothesis of one cointegrating vector can be rejected at 5 per cent and cannot be rejected for more than one cointegrating vectors at 5 per cent, which implies that there is only one cointegrating vector. For that reason, the variables GDP per worker, FDI, domestic investment, exports and higher education are cointegrated and there is a long-run relationship between them in Greece over the examined period.

The estimated cointegration relationship is presented in the following equation (t-statistics in parentheses):

$$\ln q = 0.48 \ln k_d + 0.04 \ln k_f + 0.38 \ln ex + 0.11 \ln h \quad (4)$$

(9.56)*** (2.69) *** (8.38) *** (3.04) ***

From the equation above it can be concluded that, in the long-run, domestic physical capital investment ($\ln k_d$), FDI ($\ln k_f$), exports ($\ln ex$) and higher education ($\ln h$) have a significant positive effect on economic growth. All the coeffi-

cients are statistically significant at the one per cent level. More specifically, the elasticity of GDP per worker (q) with respect to domestic investment is 0.48. This means that a one per cent increase in domestic investment will boost economic growth by about 0.48 per cent. Furthermore, the elasticity of GDP per worker with respect to FDI is 0.04. This means that a one per cent increase in FDI will boost economic growth by about 0.04 per cent. In addition, the elasticity of GDP per worker with respect to exports is 0.38. This means that a one per cent increase in exports will boost economic growth by about 0.38 per cent. Finally, the elasticity of GDP per worker with respect to higher education is 0.11. This means that a one per cent increase in higher education will boost economic growth by about 0.11 per cent.

Table 3: Johansen and Juselius cointegration test GDP per worker, foreign and domestic investment, exports and higher education: sample 1970-2012

Series: $\ln q$ $\ln k_d$ $\ln k_f$ $\ln ex$ $\ln h$					
Hypothesised No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	Max-Eigen Statistic	5 Percent Critical Value
None*	0.7046	103.105	69.818	50.001	33.876
At most 1	0.4600	53.104	47.856	25.785	27.584
At most 2	0.3390	27.318	29.797	16.979	21.131
At most 3	0.1783	10.339	15.494	8.0548	14.264
At most 4	0.0542	2.2848	3.8414	2.2848	3.8414

Notes: ^a r indicates the number of cointegrating relationships. Trace and Maximum Eigen test statistics are compared with the critical values from Johansen and Juselius (1990).

*Trace and Max-Eigen tests indicate 1 cointegrating equation at the 5% level. ^b Lags interval: 1 to 1

These findings are consistent with most of the literature review mentioned above. Specifically, the positive result of the cointegration equation with respect to domestic and foreign investment, exports and higher education, is in line with the studies that examine the case of one country, such as Jordaan and Eita (2007) for Namibia, Loening (2005) for Guatemala, Pegkas and Tsamadias (2014) for Greece, Dritsaki et al (2004) for Greece, Anwar and Nguyen (2011) for Vietnam and Shahbaz and Rahman (2010) for Pakistan.

3.3.3 Vector Error Correction Model and the Granger causality test

Having verified that the variables are cointegrated, the vector error-correction model can be applied. The vector error-correction model can give the correction term that reflects influences of the deviation of relation between variables from long-term equilibrium upon short-term changes. The size and statistical significance of the error-correction term measures the extent to which each

dependent variable has the tendency to return to its long-run equilibrium. The lagged residuals from the cointegrating regression with the appropriate number of lags are included in the Granger causality test structure. The vector error-correction model passes all the standard diagnostic tests for residual serial correlation, normality and heteroscedasticity. The results⁴ of the vector error-correction model show that the growth rate of labour has a negative and statistically significant impact on GDP per worker. All the dummy variables have a negative and statistically significant influence on GDP per worker.

The next step is to examine short-run and long-run Granger causality between GDP per worker, domestic investment, foreign investment, exports and higher education. Although the existence of a long-run relationship between these variables suggests that there must be Granger causality in at least one direction, it does not indicate the direction of temporal causality between the variables. The direction of the causality in this case can only be determined by the F-statistic and the lagged error-correction term (ECT). While the t statistic on the coefficient of the lagged error-correction term represents the long-run causal relationship, the F-statistic on the explanatory variables represents the short-run causal effect (Narayan and Smyth, 2006). More specifically, the Wald-test applied to the joint significance of the sum of the lags of each explanatory variable and the t-test of the lagged error-correction term will imply statistically the Granger exogeneity or endogeneity of the dependent variable.

The non-significance of ECT is referred to as long-run non-causality, which is equivalent to saying that the variable is weakly exogenous with respect to long-run parameters. The absence of short-run causality (Granger causality in the strict sense) is established from the non-significance of the sums of the lags of each explanatory variable. Finally, the non-significance of all the explanatory variables, including the ECT term in the VECM, indicates the econometric strong-exogeneity of the dependent variable that is the absence of Granger-causality (Hondroyannis and Papapetrou, 2002).

Table 4 reports the findings for the endogeneity of GDP per worker, domestic investment, FDI, exports and higher education, based on the error-correction equations. The error-correction term measures the proportion by which the long-term imbalance in the dependent variable is corrected in the short-run period. The negative sign, the size and statistical significance of the error-correction term measures the extent to which each dependent variable has the tendency to return to its long-run equilibrium. Estimates of the parameters show that the error-correction term measuring the long-run disequilibrium is negative and statistically significant for GDP per worker equation at the one per cent significance level. The t-test for the GDP per worker error-correction term indicates the significance of the long-run causal effect at the one per cent level. This confirms the result of the cointegration test: only GDP per worker is not a weakly exogenous variable. In addition, the t-tests of the error-correction term for the domestic investment, foreign investment and

higher education variables are not statistically significant, while for exports it is statistically significant at 10 per cent, but it is positive. These results imply that the domestic investment, foreign investment, exports and higher education are weakly exogenous variables.

In the long-run, there is unidirectional Granger causality running from domestic investment, foreign investment, exports and higher education to GDP per worker. In the short-run dynamics, the Wald tests indicate that there is unidirectional Granger causality running from domestic investment, exports and higher education to GDP per worker. Also, the results show that there is a bidirectional Granger causality relationship between GDP per worker and foreign investment; and unidirectional Granger causality running from domestic investment to exports. There is no other causality identified between GDP per worker, domestic investment, foreign investment, exports and higher education, neither in the short-run nor the long-run. Finally, the significance levels associated with the Wald tests of joint significance of the sum of the lags of the explanatory variable and the error-correction term, provide more information on the impact of domestic investment, foreign investment, exports and higher education on economic growth and vice versa. Only for GDP per worker and exports do the results indicate Granger-endogeneity. Finally, the empirical results reveal that for all variables except for higher education, we can reject the hypothesis of strong exogeneity. This means that there is a relationship between domestic investment, foreign investment, exports, higher education and economic growth in Greece.

The finding of causality is consistent with the literature reviewed above. Specifically, studies which examined the case of one country and found unidirectional causality running from domestic and foreign investment, exports, higher education to economic growth include Chowdhury and Mavrotas (2003) for Malaysia and Thailand, Shirazi and Manap (2004) for Pakistan, Alici and Ucal (2003) for Turkey, De Meulemeester and Rochat (1995) for Japan, United Kingdom, France and Sweden, Ahmad *et al* (2004) for Pakistan, Dritsaki *et al* (2004) for Greece and Pegkas and Tsamadias (2014) for Greece.

3.3.4 Impulse response functions

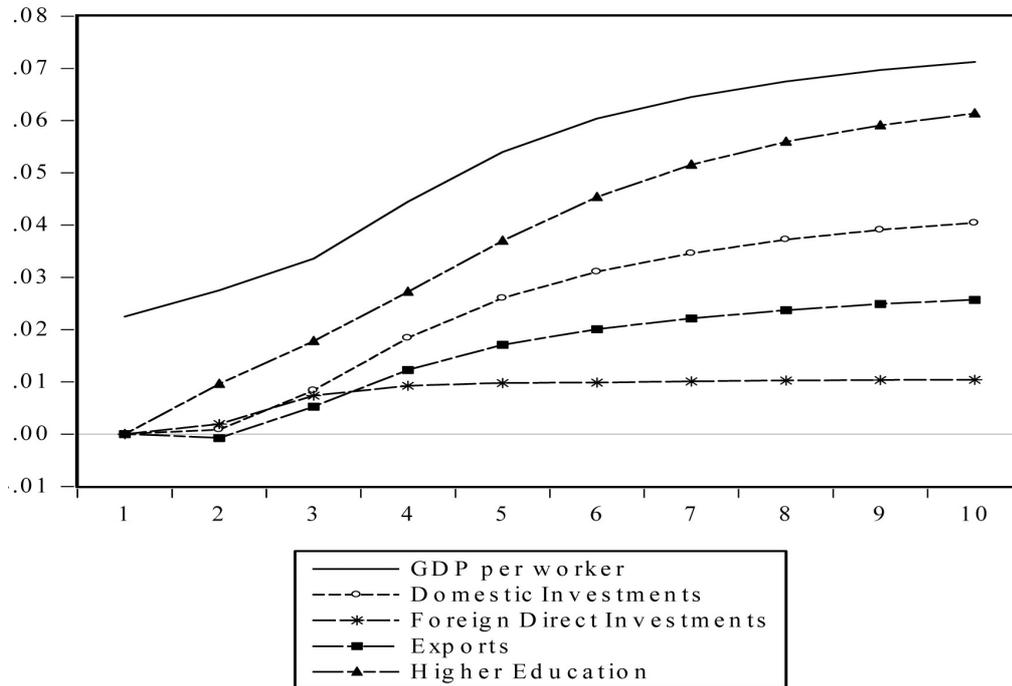
In order to study the dynamic properties of the VAR model, impulse response function (IRF) analysis is applied, using the Cholesky decomposition. The IRF is the dynamic response of each dependent variable to other variables contained in the VAR model, for a standard deviation shock to the system. These functions show the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. In other words, this approach is designed to show how each variable responds over time to an earlier shock in that variable, and to shocks in other variables. The time period of IRF spreads over ten years, which is long enough to capture the dynamic interactions between domestic investment, foreign investment, exports and higher education to economic growth. The IRF⁵ derived from the unrestricted VAR is illustrated in Figure 1.

Table 4: Summary of tests for weak and strong exogeneity of variables based on vector error correction model

	Short-run dynamics non-causality					Weak exogeneity	Tests of Granger non-causality (joint short run dynamics and ECT)					Test for strong exogeneity
	Dq	Dk _d	Dk _y	Dex	Dh		Dq and ECT	Dk _d and ECT	Dk _y and ECT	Dex and ECT	Dh and ECT	
Dq	—	6.99*** (0.008)	5.99** (0.02)	3.53* (0.06)	3.81** (0.05)	-0.275*** [-2.49]	—	13.45*** (0.001)	15.09*** (0.000)	8.46** (0.014)	23.49*** (0.000)	65.06*** (0.000)
Dk _d	0.12 (0.720)	—	0.52 (0.46)	0.08 (0.77)	1.26 (0.26)	0.161 [0.34]	0.64 (0.723)	—	2.31 (0.314)	0.68 (0.709)	0.15 (0.924)	12.26** (0.031)
Dk _y	5.14** (0.02)	0.45 (0.49)	—	0.89 (0.34)	2.63 (0.104)	1.47 [0.71]	5.64* (0.059)	1.13 (0.567)	—	1.91 (0.384)	0.91 (0.632)	11.02* (0.051)
Dex	2.01 (0.15)	4.79** (0.02)	0.33 (0.56)	—	2.16 (0.14)	0.38* [1.95]	11.22*** (0.003)	7.69** (0.021)	5.52* (0.063)	—	5.83* (0.054)	37.02*** (0.000)
Dh	0.19 (0.66)	0.01 (0.93)	1.33 (0.24)	0.01 (0.99)	—	-0.23 [-1.13]	1.81 (0.40)	1.61 (0.44)	1.54 (0.461)	1.50 (0.470)	—	3.80 (0.577)

Notes: The Wald test statistics reported are distributed as a chi-square distribution with degrees of freedom the number of restrictions. The p-values are presented in parentheses. In the short-run dynamics, asterisks indicate rejection of the null hypothesis that there is a short-run non-causal relationship between the two variables. The asterisks of the lagged ECTs are distributed as t-statistics and indicate rejection of the null hypothesis that the estimated coefficient is equal to zero (weak exogeneity). The t-statistics are presented in brackets. Finally, in the tests for Granger non-causality and strong exogeneity, asterisks denote rejection of the null hypothesis of Granger non-causality and strong exogeneity respectively. The asterisks indicate the following levels of significance: *10%, **5% and ***1%.

Figure 1: Impulse Response Function for GDP- Combined Graphs
(Response of GDP to Cholesky One S D Innovations)



First and foremost, from Figure 1 it becomes apparent that a one standard deviation shock of all the variables has a positive impact on economic growth. More specifically, a one standard deviation innovation in domestic investment causes a 0.03 per cent increase in economic growth. Similarly, a one standard deviation innovation in FDI causes a 0.01 per cent increase in economic growth. Furthermore, a one standard deviation innovation in exports causes a 0.02 per cent increase in economic growth; and finally, a one standard deviation innovation in higher education causes a 0.06 per cent increase in economic growth. The conclusion of the IRF results is that the response of economic growth to a one standard deviation shock in domestic investment is positive and bigger than for FDI and exports. But the strongest positive impact arises from higher education to economic growth.

3.3.5 Variance decomposition analysis

The variance decomposition (VDC) is now estimated for each variable in the VAR models, for a period of ten years. VDC provides information about how much of the forecast error variance for each endogenous variable in the VAR model can be explained by each disturbance. A shock to a particular variable

will affect that variable directly, but this shock will also generate variations to all other variables in the system, through the dynamic structure of the VAR model. The VDC estimation results⁶ are presented in Table 5.

Table 5: Variance Decomposition

<i>Period</i>	<i>Variance Decomposition of q</i>					
	<i>SE</i>	<i>q</i>	<i>k_d</i>	<i>k_f</i>	<i>ex</i>	<i>h</i>
1	0.02247	100	0	0	0	0
2	0.03688	92.8681	0.05454	0.28243	0.03917	6.75564
3	0.05436	80.8388	2.39816	1.97410	0.96219	13.8267
4	0.07906	69.8937	6.54981	2.30725	2.86319	18.3859
5	0.10772	62.7788	9.37265	2.06993	4.06533	21.7132
6	0.13702	58.2225	10.9432	1.79986	4.65865	24.3756
7	0.16547	55.122	11.8739	1.60712	4.98657	26.4103
8	0.19266	52.9339	12.4874	1.47011	5.19681	27.9116
9	0.21844	51.3463	12.9168	1.36868	5.34106	29.0271
10	0.24280	50.1626	13.2263	1.29116	5.44224	29.8775

The variables of the VAR order as following: GDP per worker, domestic investment, foreign direct investment, exports and higher education (q, kd, kf, ex, h respectively).

Over time, domestic investment, exports and higher education gradually affect the variation of economic growth more significantly. More precisely, 13.22, 5.44 and 29.87 per cent, respectively, of economic growth forecast error variance in a ten year period is explained by disturbances of domestic investment, exports and higher education. 2.30 per cent of economic growth forecast error variance is explained by disturbances of foreign investment until the fourth year, while in the following years the variation is decreased. One explanation could be that FDI represents a channel for international technology transfer. Increased technological levels in the FDI host sector can be transmitted to the rest of the domestic economy through a spillover effect. In Greece, this effect holds for about four years, then the positive impact of this effect is transferred to other production factors.

To conclude, higher education innovation explains much more than the other variables the variation of economic growth. This figure is quite substantial, underlying the importance of higher education on economic growth. The fact that both IRF and VDC experience a stronger and longer reaction of economic growth to a shock in higher education than shocks in other variables is supported by the hypothesis that higher education influences economic growth more than the other variables. These results are consistent with those of the long-run causality tests mentioned above. The overall results from VDC

seem to be in agreement with those of IRF, providing evidence in favour of the importance of higher education, domestic investment, exports and FDI, to explain variation in economic growth.

4. CONCLUDING REMARKS

The main objective of this study has been to investigate empirically the causal relationship between FDI, domestic investment, exports, human capital and economic growth in Greece, over the period 1970-2012. The literature suggests that there are causal relationships between these variables. The results indicate a positive relationship between FDI, domestic investment, exports and higher education with economic growth. The study estimates the effect of these variables on economic growth using the augmented neoclassical model of Mankiw *et al* (1992). The empirical analysis reveals that in the long-run, the variables are cointegrated. This implies that long-run movements of the variables are determined by an equilibrium relationship. In both the long-run and short-run, there is unidirectional Granger causality running from FDI, domestic investment, exports and higher education to GDP per worker. Also, in the short-run there is unidirectional Granger causality running from GDP per worker to FDI and unidirectional Granger causality running from domestic investment to exports.

The role of the examined variables on economic growth are found to be significant. The results of a positive contribution of FDI, domestic investment, exports and higher education on economic growth are consistent with most of the studies mentioned in the literature review. The most noticeable result is the low contribution of FDI to economic growth in Greece. One explanation could be that, in Greece, economic growth is influenced not only by the level of FDI, but also by the efficiency of these investments. Also, another important explanation for the low contribution of FDI to economic growth could be the low quality of education. The quantity of human capital has increased rapidly in recent decades, but the quality of education remains low (as confirmed by the PISA 2012 Results from the OECD). In addition, a connection of education, especially at higher levels, is required with research and development, innovation and entrepreneurship.

Therefore, in Greece, as a developed country and member of the euro-zone, many important structural reforms in various sectors need to be implemented, in order to further improve the competitiveness of the economy and to attract foreign and domestic investors, to increase exports and to improve the quality of human capital. In this case, the country may be expected to return to high growth rates. Major prerequisites are macroeconomic stability and a reduction in market distortions. Finally, regarding future research, two areas seem to be most promising: first, an investigation in pairs of the relationship between these determinants of economic growth in Greece and, second, an investigation into the promotion of cooperation among higher education, research and technological development, innovation and FDI in Greece.

We believe that these are crucial variables for the development of Greece in an internationally competitive and dynamic global environment.

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ENDNOTES

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2. This variable was taken as exogenous in this model, because the Mankiw *et al* (1992) model assumes exogenous rates of labour, technology and depreciation rate of capital.
3. In addition, following Johansen and Juselius (1990) and Lutkepohl *et al* (2001), we note that if the Johansen test gives a different result between the trace and maximum eigenvalue statistics, the latter is preferred.
4. The results of VECM are available from the authors upon request.
5. The overall results of IRFs are available from the author upon request.
6. The overall results of VDCs are available from the author upon request.

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The effectiveness of R&D and external interaction for innovation: Insights from quantile regression

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ABSTRACT

This paper utilises censored quantile regression techniques to analyse the impact of various forms of innovation inputs on the innovation output of a sample of Irish firms, using data from the Irish Community Innovation Survey 2008-2010. While there is a substantial literature on the drivers of innovation, there is a new and growing research interest in the application of quantile regression in the context of innovation. The advantage of quantile regression is that it moves beyond the typical assumption of variation around a mean, and allows for insights into the changing effectiveness of innovation inputs across the full innovation distribution. However, most papers treat innovation output as a continuous variable, when in fact it is more accurate to treat this variable as censored. Therefore, this paper applies a censored quantile regression estimator to evaluate the impact of innovation inputs on innovation output and to assess whether the effectiveness of these inputs varies, depending on how innovative a firm is. The key results of the paper are that both intramural and extramural R&D decline in effectiveness as firms become more innovative. We also find evidence that external networking is more important for less innovative firms.

1. INTRODUCTION

NOW MORE THAN EVER FIRMS ARE FORCED TO INNOVATE. To survive, to grow, and to secure a competitive advantage they must continuously challenge what they do, challenge themselves to come up with new and different ways of doing things, and constantly improve on the things they already do (Greisendorf 2009). Drucker (1998 p 149) defines innovation as ‘the means by which the entrepreneur either creates new wealth-producing resources or endows existing resources with enhanced potential for creating wealth’, whilst Edwards and Gordon (1987 p 1) define it as ‘a process that begins with an idea, proceeds with the development of an invention, and results in the intro-

duction of a new product, process or service to the marketplace'. Firms engage in various innovative activities which allow them to grow faster, better and smarter than their competitors. But should all firms innovate in the same way? Should the rare innovator, the average innovator, and the star innovator engage in the same type of research and development (R&D) and should they source knowledge from the same place? This paper addresses these issues.

We focus on internal and external drivers of innovation, assessing whether the impact of innovation inputs is consistent for all innovators, or whether the impact varies depending on how innovative a firm is. We use data from the Irish Community Innovation Survey (CIS) 2008-2010 (CSO, 2010) to specify and estimate an innovation production function which relates innovation inputs to innovation outputs (Jaffe 1986; Griliches 1995). However, unlike standard estimations of innovation production functions, which commonly use probit and logit models and, less commonly, ordinary least squares (Roper et al 2008; Hall et al 2009; Doran and O'Leary 2011), we employ censored quantile regression techniques. Very few papers focus on the application of quantile regressions in an innovation context (for exceptions see Coad and Rao 2006, 2008; Ebersberger et al 2010) and these papers typically treat innovation output as a continuous variable.

However, we argue that it is more appropriate to treat innovation output as a censored variable, which is truncated at zero. Therefore, we employ the censored quantile regression method developed by Chernozhukov et al (2015). Through the use of this methodology we can assess whether innovation output is altered in different ways, depending on which part of the innovation distribution we consider, while also controlling for the fact that innovation output is truncated at zero (as firms cannot be negative innovators). It is this new methodological approach which is the main contribution of our paper.

Another relatively novel element of this paper is the focus on innovation turnover, as oppose to binary indicators of innovation output. Specifically, we focus on the natural logarithm of turnover per employee derived from product innovations. The advantage of looking at this form of innovation is that we are not simply looking at the occurrence of innovation, but at the intensity of innovation within the firm (Roper 2001). This alternative measure of innovation output is relatively underutilised in innovation studies, which typically focus on binary indicators of innovation output. However, a problem occurs in utilising innovation turnover, as not all firms are innovators. Therefore, we adopt a two-step methodology in addressing this issue, in line with the work of Crépon *et al* (1998, henceforth CDM), to ensure that our analysis does not suffer from sample selection bias. In the first step, we estimate an innovation decision equation, which controls for firms' decisions to engage in innovation activities. This is accomplished through the use of a standard probit model. We derive an inverse Mill's ratio from this estimation for inclusion in our censored quantile regression analysis, which focuses only on innovative firms, and measures the intensity of innovation using our innovation turnover per

employee measure. This two-step approach is standard in the literature, however to the authors' knowledge no paper has utilised a censored quantile regression model in the second stage.

The remainder of this paper is structured as follows. Section 2 briefly describes the relevant literature for our analysis. Section 3 introduces the data set. Section 4 presents the empirical model to be estimated. Section 5 presents and discusses our empirical results. The final section concludes.

2. LITERATURE REVIEW

We present a brief review of the literature relevant to our paper in this section. The key literature we discuss focuses on (i) the importance of innovation, (ii) the different innovation inputs likely to impact innovation output and (iii) the value of using quantile regressions to provide insights into the innovation process of firms.

2.1 The Importance and Measurement of Innovation

There is a substantial literature which notes the importance of innovation for the growth and development of firms, regions and countries. Ultimately the goal of innovation is not innovation itself but some form of benefit for business productivity or profitability. Studies by Klomp and Van Leeuwen (2001, 2006), Janz *et al* (2003), Love and Mansury (2007), Roper *et al* (2008) and Hall *et al* (2009) have shown the importance of innovation for firm performance. For example, Klomp and Van Leeuwen (2006) find that innovation success has a positive effect on productivity, and Roper *et al* (2008) find that innovation output positively affects firms' sales and employment growth.

Given the importance of innovation for productivity, there has been a substantial number of studies conducted on the drivers of innovation. These include papers focusing on what determines the likelihood of innovation output, the proportion of sales derived from innovative goods and services, and the value of innovation turnover. These studies focus on a variety of different drivers such as the geography of innovation (Jaffe 1986; Jaffe *et al* 1993), the importance of external knowledge sources for innovation (Freel 2000b, 2003) and the role of R&D in the innovation process (Crépon *et al* 1998).

In addition to different drivers of innovation, there is also much discussion in the existing literature as to the measurement of innovation. A variety of alternative innovation indicators are used, such as binary indicators of whether a firm innovated, or not, percentage of sales which are derived from new or improved products or services, or the turnover derived from new innovations (Freel 2003; Griffith *et al* 2006; Love and Mansury 2007; Roper *et al* 2008; Doran and O'Leary 2011). Indeed the Oslo Manual (2005) notes that there are many different methods of categorising innovation output, but that studying the turnover from innovative goods and services can provide insights into the innovative performance of firms, which is not possible with simple binary indicators of innovation output. One limitation of this innovation

turnover variable is that it is constrained to certain forms of innovation, and does not consider process or organisational innovation and, therefore, while providing information on innovation success we are confined to studying product innovation. On the other hand, utilising this measure of innovation provides a mechanism to distinguish between the levels of innovativeness of firms. This has been exploited by authors such as Coad and Rao (2006, 2008) and Ebersberger *et al* (2010), who utilise quantile regression to analyse whether the determinants of innovation output vary according to how innovative a firm is.

The current paper seeks to exploit this underutilised innovation measure through the application of a censored quantile regression model, building upon the work of Ebersberger *et al* (2010) to provide insights into firms' innovation processes which are not observable using standard binary indicators of firms' innovation outputs.

2.2 Innovation inputs

As noted, the literature on innovation suggests that there are a large and diverse number of inputs important for the innovation process. These range from internal inputs to external sources of knowledge. Most studies of innovation highlight the particular importance of R&D for innovation output. Cohen and Levinthal (1989) assert that R&D plays a crucial role in the development of new knowledge and in enhancing firms' absorptive capacity. They note that firms which invest in R&D gain an increased ability to identify, assimilate and exploit knowledge for the generation of new innovations. This hypothesis has been tested empirically by numerous papers, such as Crépon *et al* (1998), Löf and Heshmati (2002) and Roper *et al* (2008). Cohen and Levinthal (1990) suggest that by undertaking R&D, firms can develop higher levels of absorptive capacity, improving their ability to recognise and assimilate valuable knowledge.

The decision to engage in intramural (internal) R&D rather than extramural (external) R&D has received much attention in the literature (Cohen and Klepper 1996; Love and Roper 2001; Love and Roper 2002; Freel 2003; Cassiman and Veugelers 2006; Love and Mansury 2007; Roper *et al* 2008; Love and Roper 2009; Vega-Jurado *et al* 2009). Geyskens *et al* (2006) argue that the decision is related to transaction cost economics, Stanko and Calantone (2011) argue that it relates to resource based economics, whilst Mudambi and Tallman (2010) argue that a combination of these paradigms is needed to explain the decision. According to transaction cost economics, intramural R&D is preferred when transaction costs are excessive. These relate to adaptation cost (i.e. the costs associated with adjusting contracts with external parties in uncertain environments), safeguarding costs (i.e. the costs of monitoring the external party after a contract is in place) and measurement costs (i.e. the cost of ensuring the contract is fulfilled). Resource based economics, on the other hand, argues that firms will engage in extramural R&D

for activities not central to their resources, while protecting resources critical to their competitive advantage.

Finally, transaction value models integrate transaction costs and resource value and argue that a firm will weigh up both factors when making their decision, and that a firm may be willing to take on higher costs in order to increase the resource value of the company. Thornhill (2006) suggests that the type and size of industry may have a role to play in the firm's decision. For example, in industries where the pace of technical change is high, firms may need fast access to highly skilled workers. One way to access such experts is via extramural R&D (Mudambi and Tallman 2010). In contrast, in more stable industries there may be more time to train and to engage in internal R&D (Thornhill 2006).

A second important input into the innovation process is external interaction (Kline and Rosenberg 1986; Lundvall 1988). Lundvall (1988), Kline and Rosenberg (1986) and Nonaka *et al* (2001), in viewing interactive learning as a positive source of knowledge, suggest that external linkages can be exploited for the advancement of business innovation. When firms innovate they utilise, combine and transform existing knowledge into new products and/or processes. However, internal knowledge is often not sufficient and acquiring new knowledge from outside the organisation is frequently required (Howells 2002). Bathelt *et al* (2004) suggest that firms engage in external knowledge sourcing to complement their existing knowledge, or to overcome deficiencies in their internal knowledge. Similarly, Romijn and Albu (2002) and Gertler and Levitte (2005) note that external networking and interaction may be viewed as an important source of knowledge for innovation, with firms learning through interaction. Indeed, in the innovation value chain concept (Hansen and Birkinshaw 2007), external knowledge sources feature prominently. These external sources of knowledge are viewed as being important sources of knowledge and provide insights into the resources available to the firm as well as shifting market dynamics and trends.

As noted in Doran and Jordan (2012) apart from internal knowledge generation and external linkages, a number of firm specific factors may also affect innovation performance. Whether the firm is indigenous or foreign-owned may play a role in explaining innovation performance, which is an issue of particular relevance to Ireland given its reliance on foreign direct investment (Klomp and Van Leeuwen 2001; Jordan and O'Leary 2008; Roper *et al* 2008). Also, the size of the firm may impact on its innovation performance (Cohen and Klepper 1996).

A substantial literature has also emerged linking sectoral characteristics with innovation performance. For instance Pavitt (1984) identifies a taxonomy of four categories of firm, science-based, specialised suppliers, supplier-dominated and scale-intensive firms, based on sources and patterns of technological change. With de Jong and Marsili (2006 p 216) noting that these sources and patterns 'shape and differentiate the pattern of innovation of firms across sectors'.

We are particularly interested in this paper in the impact of R&D and external interaction on innovation output, while also controlling for size, ownership and sector. Specifically we ask what is the impact of R&D and external networking on innovation, and does it vary across the distribution of innovation output?

2.3 Quantile regression

The key contribution of this paper is the use of quantile regression to analyse whether the impact of innovation inputs varies across the innovation distribution of the firms in our sample. One could ask why it is important to consider variation across the innovation distribution. Ebersberger *et al* (2010 p 96), in the context of innovation and R&D, note that '[a]dopting a quantile approach allows researchers to gain a fuller and more complete picture of one of the key relationships that underlies economic growth'. Indeed, Koenker and Hallock (2001 p 151) note that '[t]here is a rapidly expanding empirical quantile regression literature in economics that, taken as a whole, makes a persuasive case for the value of "going beyond models for the conditional mean" in empirical economics'.

In the context of R&D and innovation, Ebersberger *et al* (2010 p 95) estimate a quantile regression for a sample of Finnish firms and note that the relationship between R&D and innovation is 'less straight forward than so far assumed'. They find that the effectiveness of R&D for innovation output varies substantially in different parts of the innovation distribution. In the context of the effect of innovation on turnover, Coad and Rao (2008) note that innovation has the strongest effect on growth for firms in the higher quantiles. Coad and Rao (2006) also analyse the impact of innovation on market value, and find that the impact of innovation varies across the distribution of market value. They find that firms with higher values of Tobin's q are particularly sensitive to innovation, while firms with lower levels of Tobin's q are not sensitive to innovation. Likewise Goedhuys and Sleuwaegen (2010) note that product innovators have a significant positive effect on the growth of firms, especially in the higher quantiles.

This paper adds to the growth literature using quantile regression in an innovation context, by utilising a censored quantile regression model. This builds on previous work by Ebersberger *et al* (2010), by addressing the specific issue of innovation output being truncated at zero. The rationale for implementing a censored model is that our data are truncated at zero, as firms cannot possess negative innovation turnover. Also we contribute to the existing literature by considering not just the impact of internal R&D on the innovation output of firms, but also the impact of extramural R&D and a range of other factors on innovation output. While previous studies have examined these types of factors, typically in a binary innovation outcome system, the use of quantile regression provides additional insights into the varying effectiveness of these innovation inputs across the full distribution of innovators.

3 DATA

The data used in this paper are derived from the Irish Community Innovation Survey 2008-2010. This survey was conducted jointly by Forfás (Ireland's national policy advisory body) and the Central Statistics Office in Ireland. The survey is directed to companies employing more than 10 persons engaged in a range of sectors. Consistent with the OECDs Oslo manual, the survey includes a reference period, which in this case is 2008 to 2010, for innovation inputs and outputs (OECD 2005). The target for the Irish CIS is the complete range of manufacturing sectors, along with selected service sectors (CSO 2010). The motivation for the CIS survey is to provide a comprehensive survey of the innovation performance of Irish firms. The survey is conducted as part of the EU-wide Community Innovation Survey project and is completed every two years (CSO 2010).

The key dependent variable in our analysis is the innovation turnover per employee of firms. This is derived from questions relating to the innovation performance of Irish firms captured in the Irish CIS. Firms are required to indicate whether they introduced a product innovation during the reference period 2008 to 2010, where a product innovation is defined as 'the market introduction of a new or significantly improved good or service with respect to its capabilities, user friendliness, components or sub-systems'. The product could be new to the market or new to the firm. 'New to the market' is defined as a new or significantly improved good or service which the firm released onto its market before its competitors, but it may already have been available in other markets. A 'new to the firm' innovation is defined as the introduction by the firm of a new or significantly improved good or service that was already available from competitors in their market.

Having defined these two forms of innovation, firms were then asked to estimate the proportion of their total turnover in 2010 that was due to new to market and new to firm innovations introduced during the 2008 to 2010 period. Using turnover figures obtained from the CSO's central business register for 2010, we use the percentage of turnover derived from innovative goods and services, regardless of whether they were new to the market or new to the firm, to generate a value of turnover from product innovations. The turnover figures are matched to the CIS data by the Irish Central Statistics Office, with the match made at the level of the local business unit. Therefore, the figures reported in the CIS and the Business Register are comparable. As is standard in the literature, we do not consider absolute turnover for innovative goods and services but the natural logarithm of turnover for innovation goods and services per employee. It is worth noting that we are considering only product innovation. We do not consider process, organisational or marketing innovation, as the CIS does not provide information on the amount of turnover derived from these forms of innovations. Therefore, we have two innovation variables. The first, our innovation decision variable, indicates whether a firm is engaged in product innovation or not and takes the form of a binary vari-

able. The second is a censored variable, lying above zero, indicating the quantity of turnover per employee derived from innovative products.

The use of the log of innovation turnover per employee allows us to analyse whether the impact of innovation inputs on innovation outputs varies depending on the innovativeness of the firm. It is impossible to address this with simple binary measures of innovation output, which only indicate whether the firm innovates or not, rather than the intensity with which the firm innovates. Therefore, while our decision to analyse innovation turnover per employee limits the scope of our analysis to just product innovation, it allows us to analyse this type of innovation in more depth. The use of alternative measures of innovation output are not possible, given the methods employed by this paper (i.e. ordinal indicators cannot be used when estimating tobit style models).

Regarding inputs into the innovation process, we consider various measures of R&D, external interaction and firm specific factors. Starting with R&D, we employ two measures; intramural and extramural R&D. Intramural R&D is defined as creative work undertaken within the firm to increase the stock of knowledge for developing new and improved products and processes, whilst extramural R&D is defined as the same activities as intramural R&D, but performed by other firms or by public or private research organisations and purchased by the firm. The use of these two forms of R&D allow us not only to assess the importance of R&D for innovation, but also whether the effectiveness of R&D conducted in-house or sourced from external sources varies.

When we consider external interaction agents, the CIS provides information on six different possible sources of external knowledge. As per Love *et al* (2014), we categorise a firm as being open to external networks if they engage in any form of external interaction. Therefore, if a firm engages in networks with their customers, suppliers, competitors, consultants, universities or public research institutes, we classify that firm as sourcing knowledge from external agencies and being open to networks.

The final variables considered are included to control for potential firm heterogeneity. We include a measure of firm size as the log of the number of employees in the firm. We also control for whether the firm is Irish owned or not, as a number of studies using the Irish CIS have indicated that Irish firms are less innovative than foreign owned firms (Doran and O'Leary 2011; Doran *et al* 2012). Finally we control for the sector in which the firm operates, as there can be considerable variation in the propensity of firms to innovate across sectors (Pavitt 1984). Unfortunately, while age has also been found to have an important impact on firms' innovation output, the Irish CIS does not include this variable and therefore we cannot include it on our model. However, we would anticipate that age and size would be highly collinear, with younger firms being smaller and older firms being larger. Therefore, while not ideal, out of necessity we assume that size may also capture age effects.

Table 1 presents the descriptive statistics of all of the variables of interest used in this study. We can see that the average innovation output per employee of firms is €113,959, with a high standard deviation of €653,979. We can also note that firms spend more on extramural R&D per employee than intramural R&D per employee, with firms' expenditure on intramural and extramural R&D being €6,157 and €1,442 respectively. The average size of the firms in our sample is 153, while 66 per cent of the firms are Irish owned.

Table 1: Summary Statistics of Data

<i>Variables</i>	<i>Mean</i>	<i>Standard Deviation</i>	<i>Min</i>	<i>Max</i>
<i>Innovation Turnover</i>	€113,959	€653,979	€0	€10,300,000
<i>R&D</i>				
Intramural R&D	€6,157	€18,621	€0	€365,727
Extramural R&D	€1,442	€9,118	€0	€223,596
<i>Networking</i>				
Backwards	29.6%	Na	0	1
Forwards	22.8%	Na	0	1
Horizontal	7.3%	Na	0	1
Public	19.8%	Na	0	1
<i>Control Variables</i>				
Size	153	461	10	10,234
Irish Owned	66%	Na	0	1

Source: Irish Community Innovation Survey

4. EMPIRICAL METHOD

The central question of this paper is the measurement of the differentiated impact of innovation inputs on innovation output, dependent upon how innovative a firm is. Therefore, we construct an innovation production function which relates innovation inputs to innovation outputs. However, as we are considering only innovative firms, we must first model innovative behaviour, as is standard with the CDM literature (Crépon *et al* 1998; Griffith *et al* 2006; Klomp and Van Leeuwen 2006). This is applied to correct for sample selection bias, as we are moving from a random sample which is representative of the population under consideration (i.e. the Irish CIS), to a non-random selection of innovative firms (i.e. only the innovative firms in the CIS). Therefore, following Doran and O'Leary (2011), we initially estimate a binary innovation decision equation. This is displayed as equation (1):

$$ID_i = \alpha_0 + \alpha_1 X_i + \mu_i \quad (1)$$

Where ID_i is a binary variable which indicates whether firm i engaged in product innovation activity or not, X_i is a matrix of control variables which may determine a firm's innovation decision,³ α_i are the corresponding coefficients and μ_i is the error term. As is standard in the CDM methodology, equation (1) is estimated using a probit model, and the inverse Mill's ratio (IMR) is derived from the equation for inclusion in subsequent analysis. The use of the IMR in subsequent equations mitigates for sample selection bias, as the remainder of the analysis no longer deals with a random sample of firms, but only the innovators from the original random sample (Doran and O'Leary 2011).

Following from our first stage estimation, we start the main element of our analysis by specifying an innovation production function with the log of innovation turnover per employee as our dependent variable; and we run our analysis only for innovative firms. This function relates innovation inputs to innovation outputs and is standard in the innovation literature (Griliches 1995; Crépon *et al* 1998; Griffith *et al* 2006).

$$IO_i = \beta_0 + \beta_1 R \& D_i + \beta_2 EI_i + \beta_3 Z_i + \beta_4 IMR_i + \varepsilon_i \quad (2)$$

where $ID_i = 1$. In equation (2) IO_i is the log of the turnover per employee derived from innovative products or services for firm i (where $i=1, \dots, N$). $R\&D_i$ is a N by 2 matrix containing information on the log of intramural and extramural R&D expenditure per employee. β_1 is the 2 by 1 vector of coefficients. EI_i is a binary indicator of whether firm i engaged in any form of networking activity. β_2 is the associated coefficient. Z_i is a matrix containing a series of control variables which may impact on the likelihood of a firm innovating. These are the size of the firm, whether the firm is Irish owned or foreign owned and the sector the firm operates in. β_3 is the associated vector of coefficients. IMR_i is the inverse Mill's ratio derived from equation (1). ε_i is the error term.

When it comes to estimating the innovation production function, the standard approach is to use logit or probit models when the innovation indicator is binary (Griffith *et al* 2006; Hall *et al* 2009), some variation of OLS if the variable is continuous (Crépon *et al* 1998) or a censored regression, such as a tobit model, if the innovation indicator is the proportion of sales from innovative good or services (Roper 2001). We build upon the approach used by Ebersberger *et al* (2010), which is one of the few papers to use quantile regression. However, rather than utilising a standard quantile regression, we note that our data are essentially censored at zero, as the dependent variable is innovation turnover per employee. Therefore, we employ a censored quantile regression model to take account of the censored nature of the data. The advantage of quantile regression is that it allows the coefficients to vary over

the distribution of the dependent variable. It can explain the determinants of the dependent variable at any point of the distribution of the dependent variable (unlike OLS which is limited to explaining the mean of the dependent variable). Therefore, we can assess whether the contribution of R&D and knowledge sourcing inputs to innovation output are the same for average, rare and star innovators.

The estimator employed is that developed by Chernozhukov *et al* (2015), which is a censored quantile regression estimator based on the censored quantile regression model developed by Powell (1986). The advantages of utilising this estimator in the innovation production function context is that it enables an analysis of the effect of innovation inputs on innovation output, allowing for the importance of innovation inputs to vary across quantiles while also controlling for the censored nature of the data, whereby firms cannot possess an innovation output of less than zero. For a detailed discussion of the estimator we refer the interested reader to Chernozhukov *et al* (2015) and for an example of this estimator in practice, see Kowalski (2015).

5. RESULTS

Regarding the estimations of our empirical model, we present graphs of the coefficients and their confidence intervals from the censored quantile regression estimation of equation (2) in Figure 1; and a table of coefficients in Table 2. Specifically we focus our discussion on the role on intramural and extramural R&D (as well as their interaction), engaging in networks, and size, on the innovation output of firms.

Regarding Figure 1, we present a separate graph for each of our independent variables (with the corresponding coefficients presented in Table 2). The Y-axis shows the magnitude of the coefficient estimates, while the X-axis shows the quantile used in the estimation. The quantiles range from 10 to 90, with 50 being the median. A horizontal line would indicate that the coefficients do not vary across quantile, implying that regardless of the portion of the distribution we analyse, the impacts of the independent variables are constant. However, we can see clearly that all of the graphs appear to exhibit non-horizontal trends, implying that the impact of the coefficients varies over the distribution. The dark shaded area of the graphs corresponds to the confidence intervals of the coefficients.

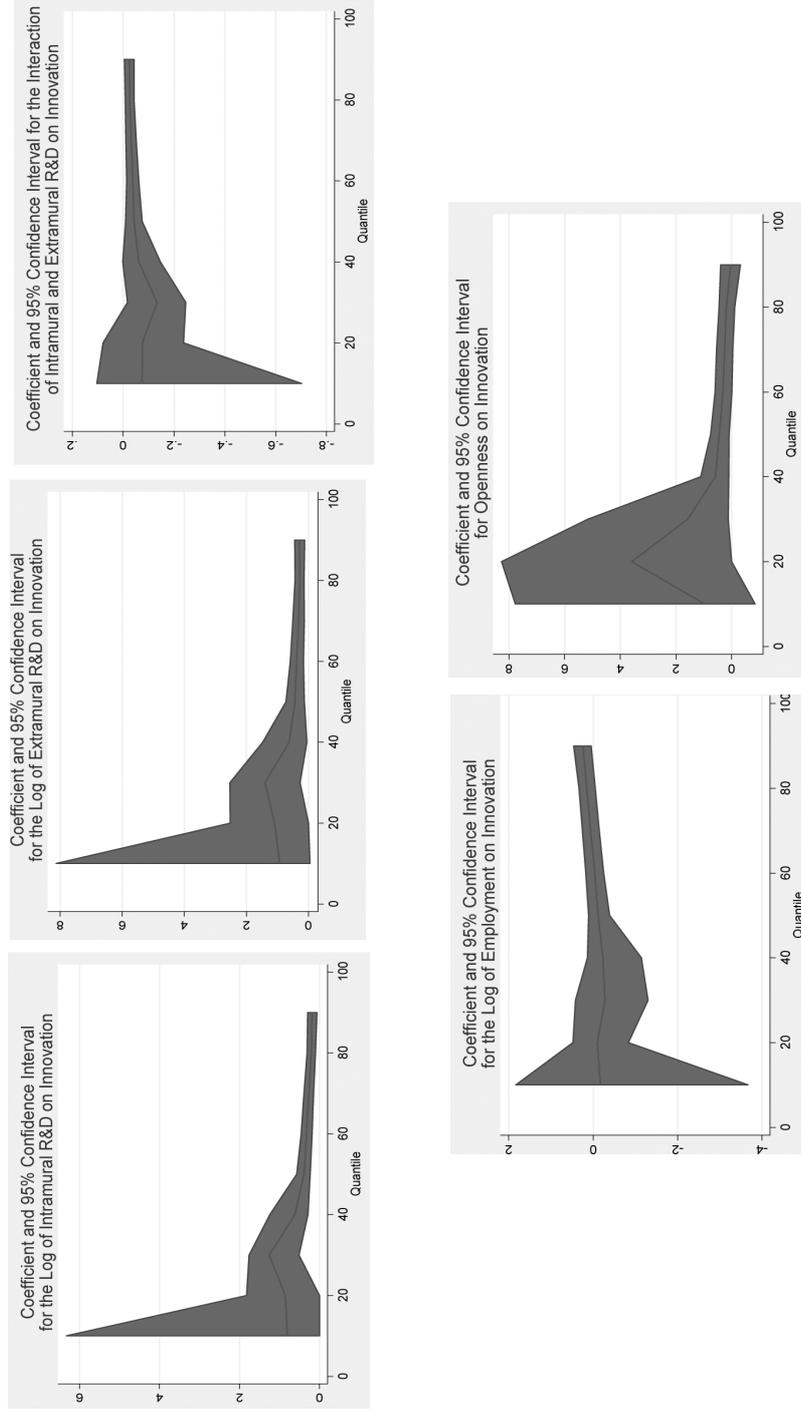
Beginning with intramural R&D, we note that this has a consistent positive effect on innovation output. However, there is a pronounced downward trend in the magnitude of the coefficient after the 30th percentile. This suggests that as we approach higher levels of innovation output, the return to each additional unit of intramural R&D per worker diminishes. It would appear that less innovative firms gain more of a benefit from each additional euro of R&D than more innovative firms. This may be due to diminishing returns to R&D as firms become more innovative. Firms which have little inno-

Table 2: Estimates of Censored Quantile Regression Estimation of Equation (2)

Quantile	10	20	30	40	50	60	70	80	90
<i>Intramural R&D</i>									
Lower 95% CI	0.0000	0.0000	0.5162	0.2916	0.2319	0.1846	0.1497	0.0987	0.0608
Coefficient	0.8007	0.8572	1.2592	0.6143	0.3872	0.3259	0.2641	0.2015	0.1853
Upper 95% CI	6.3251	1.8249	1.7594	1.2395	0.5715	0.4597	0.3913	0.3088	0.2940
<i>Extramural R&D</i>									
Lower 95% CI	-0.0548	0.0000	0.2665	0.0404	0.1276	0.1607	0.1284	0.1325	0.1167
Coefficient	0.9251	1.0815	1.3973	0.6176	0.4264	0.3752	0.3124	0.2735	0.2849
Upper 95% CI	8.1328	2.5185	2.5319	1.4685	0.7189	0.5828	0.4955	0.4267	0.4360
<i>Interaction term R&D</i>									
Lower 95% CI	-0.7026	-0.2379	-0.2463	-0.1459	-0.0748	-0.0616	-0.0513	-0.0429	-0.0427
Coefficient	-0.0731	-0.0761	-0.1329	-0.0610	-0.0423	-0.0381	-0.0310	-0.0256	-0.0247
Upper 95% CI	0.1047	0.0789	-0.0167	0.0020	-0.0090	-0.0126	-0.0106	-0.0085	-0.0039
<i>Log of Employment</i>									
Lower 95% CI	-3.6681	-0.8289	-1.2966	-1.1406	-0.3868	-0.2514	-0.1412	-0.0490	0.0505
Coefficient	-0.1737	-0.1018	-0.2750	-0.2362	-0.1162	-0.0393	0.0649	0.1525	0.2441
Upper 95% CI	1.8311	0.4748	0.4201	0.1405	0.1040	0.1705	0.2584	0.3375	0.4591
<i>Open to Networking</i>									
Lower 95% CI	-0.8376	0.0000	0.1212	0.1022	0.0975	-0.0127	-0.0424	-0.1127	-0.3116
Coefficient	0.9793	3.5837	1.5904	0.5930	0.4365	0.3193	0.2523	0.1915	0.0352
Upper 95% CI	7.7697	8.2610	5.1700	1.1183	0.7587	0.5949	0.5423	0.4512	0.3953
<i>Irish Owned</i>									
Lower 95% CI	-0.5394	-0.4263	-0.1015	-0.2325	-0.4007	-0.5195	-0.6178	-0.8147	-1.3840
Coefficient	1.5738	2.4646	1.3480	0.4389	0.0560	-0.1411	-0.2653	-0.3738	-0.7617
Upper 95% CI	11.0386	9.5760	2.9389	1.3784	0.5819	0.2523	0.1596	0.0683	-0.2436

Notes 1: Controls for sector are also included but not presented here due to space constraints. 2: The estimation method used is the censored quantile regression developed by Chernozhukov et al (2015).

Figure 1: Selected Coefficients and Confidence Intervals from Estimation of Equation (2)



vation output may gain more of a benefit from R&D, as the additional technological steps to acquire new knowledge may be lower than firms with higher levels of innovation output, if we assume that more innovative firms are operating at the technological frontier. This corresponds with Thornhill (2006), who suggests that in industries where the pace and magnitude of change is fast, firms need quick access to highly skilled workers, whereas in slower industries there is time to train employees and to conduct in-house R&D.

Regarding extramural R&D we observe a very similar pattern occurring. While the effects seem to be slightly larger than intramural R&D, the largest positive effect again occurs around the 30th percentile. Again, it would thus appear that less innovative firms gain more of a benefit from each additional euro of R&D than more innovative firms, suggesting diminishing returns to R&D as firms become more innovative.

We also consider the interaction of intramural and extramural R&D. We note that in this case there appears to be some degree of substitutability between these two forms of R&D. The coefficient term is consistently negative, implying that firms substitute intramural and extramural R&D. However, the confidence intervals suggest that this result is not significant for the bottom 50 per cent of firms, only becoming significant from the 50th percentile and above. This implies that at the lower end of the innovation distribution, there is no relationship between intramural and extramural R&D, but as firms become more innovative they substitute one for the other.

Considering the engagement of a firm in networks, we note a positive relationship between innovation output and networking. While the largest effect again occurs around the 30th percentile, we note that the confidence bands are very wide for this particular variable and often take in zero. Therefore, we are reluctant to draw any strong implications from our analysis regarding networking. While the effects appear positive, these are not statistically relevant to innovative performance.

Regarding our firm specific factors we find that size has no significant effect on innovation output. There is substantial debate in the literature as to the impact of size on innovation and its connection with R&D, with alternative studies producing conflicting results (Cohen and Klepper 1996; Freel 2000a; Hall *et al* 2009; Murro 2012). In our case we observe no scale effects.

6. CONCLUSIONS AND IMPLICATIONS

This paper analyses the determinants of the innovation output of Irish firms. The novel element of the paper is to employ censored quantile regression techniques to assess whether the return to various innovation inputs varies across the distribution of innovation output. The data used are from the Irish Community Innovation Survey 2008-2010, which surveys the innovation performance of over 2,000 Irish firms. Of necessity our analysis is confined to the analysis of product innovators, so our sample reduces to just over 900 firms.

However, in order to avoid any bias arising from sample selection issues, we estimate a two-step model, following Doran and O'Leary (2011) in the CDM literature tradition. While a number of authors analyse the drivers of innovation performance in Irish firms, none use censored quantile techniques and only a few use measures of innovation output which are non-binary.⁴

We expand upon previous studies which have used quantile regression in two ways. Firstly by utilising a recently developed censored quantile regression technique; and secondly by focusing not solely on intramural R&D, but expanding our analysis to consider other important drivers of innovation output such as extramural R&D (OECD 2005) and external interaction agents (Freel 2003; Hansen and Birkinshaw 2007). In doing so we contribute to the literature on the drivers of innovation and the extent to which the returns to innovation inputs vary across the spectrum of innovation outputs of firms.

The key results of the paper are that the returns to innovation inputs vary substantially, depending upon the portion of the innovation distribution considered. Also there is substantial variation in the types of returns observed, with no clear pattern, such as higher returns for all variables for highly-innovative firms, observed. A key finding is that the returns to intramural and extramural R&D vary significantly across the distribution of innovation output. The greatest return to intramural and extramural R&D is for less innovative firms. This suggests that firms gain more from their R&D activity at earlier levels of innovativeness; and that as they become more innovative, the effectiveness of each euro spent on R&D diminishes.

This paper opens avenues for future research into the innovation processes of firms. It notes that the returns to innovation inputs vary dramatically in the Irish case. However, there is little research which employs quantile regression in other countries and thus little opportunity for comparison across countries. Analysis of other countries' CIS data, using quantile regression, would provide scope for comparison across countries, which may show further heterogeneity in the effectiveness of innovation inputs. The procedures used here could also be employed to assess the impact of innovation on the productivity performance of firms. It may be that more or less productive firms gain more or less of a benefit from the introduction of innovations.

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ENDNOTES

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3. Where the matrix of variables includes the sector a firm operates in, the size of the firm controls for intramural and extramural R&D and whether the firm is Irish owned or not.
4. Examples of studies which use a continuous or censored measure of innovation output, but not quantile regression, are Roper *et al* (2008) and Doran and O'Leary (2011).

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The stability of the demand for money function in Islamic and non-Islamic monetary policy regimes

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ABSTRACT

This study, using quarterly data from Egypt and Iran, extends the literature on demand for money by examining the stability of money demand functions in two different monetary policy regimes, an Islamic banking system and a conventional banking system. A stable demand for money enables central banks accurately to predict the demand for money and hence attain a price stability objective through the adjustment of the money supply. This paper adopts a restructured form of Friedman's (1956) model, which considers real demand for money as an extension to the theory of demand for durable goods. The study estimates the long-run demand for money functions in Iran, which represents an Islamic banking system, and Egypt, which represents a conventional banking system. The study then examines empirically the stability of the demand for money function under two different financial systems. The study finds that the demand for money function is stable under the Islamic banking system and unstable under the interest-based banking system.

1. INTRODUCTION

THE WIDE SPREAD OF THE ISLAMIC FINANCIAL SERVICES INDUSTRY in more than seventy countries has been asymmetric regarding scale. Some countries have implemented a fully-fledged Islamic financial system (hereafter, IBS) in which the banking system follows Islamic rules and monetary policy is conducted using fully *Shariah* (or Islamic Law)-compliant instruments (e.g. Iran and Sudan). Other countries have implemented a dual-financial system in which Islamic banks (IBs) exist alongside conventional (or interest-based) banks where the monetary policy is managed by both *Shariah*-compliant instruments and conventional monetary policy instruments, (e.g. Malaysia). Many other countries have financial regulations in place to regulate the setting up of either Islamic banks or even Islamic windows inside conventional banks, where monetary policy is conducted entirely using conventional monetary policy instruments, (e.g. Egypt, Turkey and the UK: Awad 2015).

The monetary policy regime that Islamic central banks commonly adopt to achieve their goals is the monetary targeting regime. In other words, monetary policy is formulated to determine the desired (or targeted) level of money supply, (i.e., the level of money supply that insures adequate liquidity compared to the capacity of the economy to supply goods and services). The chosen level of money supply is determined by demand for money at full employment, within the framework of price stability (Chapra 1996; Fahmy 2006).

A stable demand for money function enables the central bank accurately to predict demand for money and hence control the money supply (using monetary policy instruments) in order to achieve the primary goal of monetary policy, price stability.

In general terms, the success of the monetary targeting regime hinges on two basic assumptions; (i) the relationship between the goal variable and the monetary targets must be strong enough; (i.e., money velocity is predictable), (ii) monetary aggregates must be under the control of the central bank; (i.e., the money multiplier is predictable) (Batini *et al* 2005).

Anderson (1985) identified three sources of instability of the demand for money; (i) changes in the velocity of circulation in response to fluctuations in interest rates, (ii) the demand for money function itself may shift. For instance, financial innovations and deregulation of interest rates may shift the demand for money at the prevailing levels of nominal interest rates, and (iii) over shorter periods the money stocks actually held may not correspond to the desired money balances. If the speed of adjustment is low, then the mismatch between the desired and the actual money balances will induce large and unexpected changes in the velocity of circulation, leading to an unstable demand for money function.

However, some researchers (Chapra 1996; Fahmy 2006) argue that the prohibition of nominal interest rates and the dependence on a profit-sharing ratio mechanism under Islamic banking systems (IBS) would stabilise the demand for money function. Speculative capital flows arising from interest rate differentials and exchange rate expectations are not likely to impair the stability of demand for money function under IBS. Demand deposits will pay no interest and time deposits are equity-oriented and committed for relatively longer periods. Exchange rate expectations, however, can be discouraged and their monetary effect can be neutralised.³

This paper investigates the stability of demand for money function under two varied banking systems; a fully-fledged IBS and a conventional banking system. Because of the lack of data for the Sudanese economy, the study is limited to the Iranian economy, where a fully-fledged Islamic banking system is adopted. For the purpose of comparison, the demand for money function in the Egyptian economy is estimated, where the Egyptian economy is taken to be an interest-based economy. Firstly, we estimate the long-run demand for money functions in the Iranian and Egyptian economies; and, secondly, we compare the stability of the demand for money function in the two cases under

study. A descriptive analysis is utilised to investigate the variables of the demand for money function, with econometric techniques utilised to estimate the money demand functions and test their stability.

The remainder of this paper is as follows; section two explores the variables of the demand for money functions reported in the literature. Section three highlights the variables in the demand for money function in Islamic and non-Islamic banking systems. Section four discusses data and estimation results. Section 5 offers concluding remarks.

2. VARIABLES IN THE DEMAND FOR MONEY FUNCTION

The classical quantity theory regards the holding of money as a means to facilitate transactions and has no intrinsic utility. According to Fisher's (1911) 'equation of exchange', the quantity of money in circulation, M_s , is related to the volume of transactions, T , and the price level of its related items, P_t , through a proportionality factor, V_t , called 'transactions velocity of circulation of money', that is:

$$M_s V_t = P_t T \quad (1)$$

In the Cambridge approach or cash balance approach, money is held not only as a medium of exchange but also as a store of value. According to Pigou (1917), the demand for money, M_d , other things being equal, is proportional to the level of nominal income, py , such that $M_d = kpy$. Clearly, the ratio k of nominal income that individuals hold in cash balances might depend on interest rates and the level of wealth, or even nominal income. Incorporating into the money market equilibrium condition:

$$M_s V = py \quad (2)$$

where $V (= 1/k)$ is the income velocity of circulation.

The introduction of the interest rate into the demand for money function came under the so-called 'speculative demand', incorporated by Keynes. The Keynesian demand for money function, therefore, incorporates two variables, such that:

$$M_d / P = f(y, i) \quad (3)$$

where M_d/P is the real demand for money, y stands for real income and mirrors the transaction and precautionary demand for money. i stands for the nominal interest rate and reflects the speculative demand for money.

Chapra (1996) argues that the demand for money under IBS consists of two components: transactionary and precautionary demand for money. Speculative demand for money is expected to be minimised or even absent, because of the absence of interest rates. Individuals are not expected to retain liquid balances in excess of transactionary and precautionary needs as long as they can make profits, or at least avoid the erosive effect of Zakah (a rate

of 2.5 per cent to be paid annually on liquid funds according to Islamic law) and inflation, by investing their excess liquidity in *Shariah*-compliant financial assets. Thus, transactionary demand will incorporate *Shariah*-compliant investment which has a positive relationship with the expected rate of return. Since the expected rate of return does not fluctuate greatly, as with the interest rate the transactions demand for money would be more stable under IBS.

Nonetheless, the client's share in the expected return on *Shariah*-compliant investment, $\alpha_c (= 1 - g_b = g_c) R^e$, can be regarded as a straightforward alternative to the nominal interest rate adopted by conventional banks.⁴ R^e is the expected rate of return on *Shariah*-compliant investment, g_b symbolises the profit-sharing ratio on *Mudarabah* (trust finance) and *Musharakah* (joint venture finance) investments owed to commercial banks, and $g_c (= 1 - g_b)$ is the outstanding client's profit-sharing ratio.⁵

Demand for money under IBS can be explained similarly to the Keynesian model, where a negative relationship exists between the demand for money and α_c . The higher the α_c (either because of an increase in g_c , or because of high expected rate of return, R^e , given g_c) the higher the opportunity cost of holding liquid funds, and the lower the demand for money.

Similar to the nominal interest rate, Islamic central banks can use commercial banks' profit-sharing ratio, g_b , as a monetary policy instrument.⁶ Setting g_b could be based on monetary policy directives and the expectations about the rate of return, R^e . An increase in g_b , (or equally a decrease in g_c and hence α_c) will stimulate demand for money (and vice-versa).⁷

The assumption that individuals will not hold liquid funds other than for transactionary and precautionary purposes because of the erosive effect of *Zakah* is based on an implied assumption that liquid money will remain idle for a time period of a full year. Clearly, such an assumption is not realistic where individuals under IBS can diversify their portfolios from a spectrum of Islamic financial assets, (e.g. *Sukuk*, Islamic bonds).

In light of the above discussion, the demand for money function under IBS may incorporate two variables as follows:

$$M_d / P = f \{ y, \alpha_c (= (1 - g_b) R^e) \} \quad (4)$$

Baumol (1952) and Tobin (1956) adopted what is called the 'inventory approach' to analyse the demand for money for transactionary purposes. Because of the transactions costs of selling financial assets to finance transactions, households hold an inventory of money for transactionary purposes. The household's portfolio problem under these models, therefore, is the balancing of the two competitive purposes for holding money; (i) the need to hold money for transactionary purposes because of the mismatches between receipts and expenditures, (ii) holding liquid financial assets other than money will offer higher yields while money does not. These models lead to the following formula of optimal demand for money:

$$md^* = \sqrt{(cy)/2i} \quad (5)$$

Where optimal demand for real money balances, md^* , is positively related to transactions costs, c , and real income, y , and inversely related to interest rate, i .

Other models with different approaches have investigated the demand for money for transactionary and precautionary purposes, (e.g. Milbourne 1983; Lucas 1980; Dornbusch and Fischer 1990; Cuthbertson and Barlow 1991). In addition, the store of value function of money has been considered using 'portfolio models', where demand for money is interpreted in the context of a portfolio choice problem. Tobin (1958) reinterpreted Keynes's liquidity preference on the basis of the theory of risk-aversion behaviour, where individuals hold money in their portfolio because the rate of return on holding money is more certain than the rate of return on holding earning assets. Fisher (1975), however, has indicated that risk-aversion behaviour is not sufficient to explain the reasons for holding money, because money is subject to the risk of changes in the general price level.

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In light of the above discussion, real output, y , and interest rate, i , are the key explanatory variables included in the demand function. However, another approach considers the demand for money as an extension to the theory of demand for durable goods. Similar to goods, individuals hold money because of the utility derived from it. Instead of searching for motives behind holding money, Friedman (1956) assumes that individuals hold money as a durable good. He viewed money as an 'abstract purchasing power' (i.e., individuals hold money with the intention to use it for upcoming purchases). Therefore, money competes with other assets, such as, bonds, stocks, and physical goods in individuals' and business firms' portfolios. From this perspective money services, similar to physical goods' utilities, decline as the quantity of money held increases.

The most significant variables included in Freidman's (1956) demand for money function are as follows:

$$Md / p = f(Y_p, R_b - R_m, R_e - R_m, \pi^e - R_m) \quad (6)$$

Where M_d/p is the real demand for money, Y_p stands for permanent income, R_b is the expected nominal rate of return on bonds, R_e is the expected nominal rate of return on equities, R_m is the expected nominal rate of return on money, and π^e is expected inflation.

Friedman (1956) argues that demand for money is insensitive to the interest rate. That is, when the interest rate rises the expected rate of return on money held as bank deposits, R_m , rises along with the expected rates of return on other assets. Consequently, opportunity cost variables $R_b - R_m$, $R_e - R_m$, and $\pi^e - R_m$ will not produce a significant change in the real demand for money. As a result, real demand for money is determined only by permanent income, Y_p .

3. VARIABLES IN THE DEMAND FOR MONEY FUNCTION IN ISLAMIC AND NON-ISLAMIC BANKING SYSTEMS

The present paper adopts a restructured form of Friedman's (1956) model, which considers real demand for money as an extension to the theory of demand for (durable) goods.

Similar to the theory of demand for goods, real demand for money, M_d/p , is determined by real income, y , price of money, P_c , expected price of money, P_c^e , and the relative prices of other alternatives to money (i.e. relative price of bonds, RP_b , and relative price of equities, RP_e) Thus, the demand for money function in real terms is as follows:

$$Md / p = f[y, P_c, P_c^e, RP_b, RP_e] \quad (7)$$

Real demand for money is expected to have a positive relationship with real income, y . As real income increases, real expenditure and hence demand for real balances increases. Unlike Keynes (1936) and Friedman (1956), who viewed the interest rate as the opportunity cost of holding money, or the price of foregoing liquidity, the present paper measures the price of holding liquidity in terms of the sacrificed real goods and services. The price of money is what we must give up to get it. Put simply, it is the inverse of the price level or, in aggregate, the general price level. If the price of a good X is 0.25 pounds, then the price of a pound is $4X$. If the interest rate is ten per cent, an economic agent is then thought to borrow money for ten pence in the pound. The interest rate is considered the rent on money or the price of credit, measured in money, since the economic agent is obliged to return the principal after a specific period of time. Obviously the price to borrow good X is not the same as the price to buy it. The interest rate is the price of borrowing capital rather than the price of money. It goes without saying that a change in the price of

money affects both the rented money and the money an economic agent is paying as rent, leaving the ratio of the two unchanged.⁸

On this basis, the purchasing power of a monetary unit spent on produced and consumed goods and services, P_c , can be measured by the inverse of CPI (or GDP deflator), so, $P_c = 100/\text{CPI}$. For the same reasons, the purchasing power of a monetary unit spent on shares or equities, P_e , can be measured by the inverse of share-price index ($P_e = 100/\text{share price index}$). The purchasing power of a monetary unit spent on equities relative to the purchasing power of a monetary unit spent on goods and services, $R/P_e = P_e/P_c$ is defined by CPI/share-price index, that is, $P_e/P_c = (100/\text{share price index})/(100/\text{CPI}) = \text{CPI}/\text{share price index}$.

The real demand for money is expected to have a negative relationship with the purchasing power of a monetary unit spent on goods and services, P_c . The higher the price level the lower the purchasing power of money, P_c , and hence the lower the cost of holding liquid money, the higher the demand for money.

The expected purchasing power of money, or expected price of money, P_c^e , will have a positive relationship with real money demand. Expecting a high price of money, or a high purchasing power of money, because of future deflation of prices of goods and services would encourage people to hold large real money balances at the current time.

The relative price of a monetary unit spent on equities to the price of a monetary unit spent on goods and services, $R/P_e = P_e/P_c$ (= CPI/share-price index), will have a negative relationship with real money demand. High equity prices that lower the purchasing power of a monetary unit spent on equities, relative to the purchasing power of a monetary unit spent on goods and services, where R/P_e gets lower, will decrease demand for equities and hence increase real money demand.

Similarly, the relative price of a monetary unit spent on bonds, to the price of a monetary unit spent on goods and services, $RP_b = P_b/P_c$ (= CPI/bond-price index), will have a negative relationship with the real demand for money. An increase in the price of bonds, by reducing the nominal interest rate, will lower the purchasing power of a monetary unit spent on bonds, relative to the purchasing power of a monetary unit spent on goods and services, where gets lower. Thereby, demand for bonds will decrease and demand for real money increase.

Obviously, the above mentioned variables are relevant to Islamic and non-Islamic banking systems, except for the relative price of money spent on bonds to the price of money spent on goods and services, RP_b . Under IBS, however, RP_b is substituted by the relative price of Islamic bonds, RP_s .⁹

Alternatively, the nominal interest rate in the conventional banking system is a proxy for the relative price of bonds, RP_b , since the nominal interest rate has a negative relationship with the market price, or the current value of

bonds. In addition, the client's share in the expected return on *Shariah*-compliant investment, $\alpha_c (= (1-g_b) R_e)$, can be used as a proxy for the relative price of *sukuk*, since α_c has a positive relationship with price of *sukuk* and a negative relationship with the demand for money.

4. DATA AND ESTIMATION RESULTS

Using quarterly data, we investigate the stability of the demand for money function specified by equation 7, for Egypt and Iran.¹⁰ As mentioned above, Egypt follows a non-Islamic banking system in which Islamic banks or Islamic windows inside conventional banks are allowed, but the entire banking system is managed by conventional monetary policy instruments. In contrast, Iran has followed a fully-fledged Islamic banking system since March, 1984 when the Iranian government banned the use of the nominal interest rate.¹¹ Quarterly data for Egypt are available from 2002Q1 to 2013Q4. As for Iran, quarterly data, on most variables in equation 7, are available until 2007Q4. Thus, the study will consider the Iranian case during the period from 1990Q1 to 2007Q4. We take 1990Q1 as a point of departure, as the structural change of policy might have been occurred since early 1990s when the CBI began to adopt indirect methods of conducting monetary policy immediately after the launching privatisation and structural adjustment programmes in the early 1990s. The sources of data are the IFS and databases available on CBI and CBE websites.¹²

4.1. The stability of demand for money function in Egypt 2002-2013

To check the stability of the demand for money function in Egypt, we firstly estimate the long-run money demand function, and secondly check the stability of the long-run relationship. The demand for money function in Egypt incorporates the following variables:

$$m = f(y, P_c, P_c^e, RP_e, Ti) \quad (8)$$

Where, real demand for money, m , is the nominal money supply, $M2$, divided by the GDP deflator. Real income, y , is GDP with fixed prices (2010:Q1=100). The purchasing power of money in terms of prices of goods and services, P_c , is the inverse of the CPI. The expected purchasing power of money in terms of goods and services prices, P_c^e , is the lagged value of P_c , i.e., $(P_c^e = (P_c)_{t-1})$ where expectations are assumed to be adaptive.¹³ The price of a monetary unit spent on equities relative to the price of a monetary unit spent on goods and services, RP_e , is the ratio of CPI divided by the share-price index, i.e. $RP_e = \text{CPI}/\text{share-price index}$. Because quarterly data on bond prices covering the period 2002-2013 are not available, the three-month treasury bill rate, Ti , is used as a proxy for the price of a monetary unit spent on bonds. The expect-

ed signs of the explanatory variables included in the equation 8 are $f1$ and $f3 > 0$, and $f2, f4$ and $f5 < 0$.

All variables included in equation 8 are in logs and are seasonally adjusted except for the three-month treasury bill rate, Ti .¹⁴ The unit root tests (see Table 1) indicate that all variables are integrated of order one, or $I(1)$, except for treasury bills, which are integrated of order zero, or, $I(0)$.

Table 1: ADF Test Results for Unit Roots - Egypt

Variable	Without trend	With trend	Lag length
m	-2.39*	-2.30*	(4)
Y	-1.05*	-1.42*	(4)
P_c^e	0.48*	-2.64*	(1)
RP_e	-0.79*	-1.72*	(1)
Ti	-3.11	-3.93	(0)

Notes:

1. An asterisk indicates significance at the 5 per cent level
2. The lags of the dependent variable used to obtain a white-noise residuals are determined using AIC.

The demand for money function in Egypt can be written as:

$$m_t = \beta_0 + \beta_1 y_t + \beta_2 P_c^e + \beta_3 RP_e + \beta_4 T_t + \varepsilon_t \quad (9)$$

To estimate equation 9, where the integrated variables with different orders are included, a cointegrated relationship has to exist.¹⁵ We apply stability tests in the framework of an Error Correction Model (ECM) for testing the stability of the demand for money in the two countries under study. Error Correction is a formation in which the long run equilibrium relationship between money demand and its determining factors is embedded in the equation that captures short-term dynamics (Kole and Meade 1995). One possible justification for using ECM models is that various significant structural changes come in the form of a changing causal structure, so major changes may happen while the basic long-run relationships remain stable.

Following Hansen's (1992a) approach, we estimated the parameters of equation 9 using Phillips and Hansen (1990) Fully Modified Ordinary Least Square (FM-OLS), then Hansen's (1992b) test of the null of cointegration, applied to the cointegrating residuals of FM-OLS. In the second stage, we take the residuals from the FM-OLS regression (i.e., equation 11) to estimate the ECM equation 10 by OLS, where all variables are $I(0)$, and test for structural changes.

$$\Delta m_t = c_t + \lambda u_{t-1} + \gamma_1 \Delta y_t + \gamma_2 \Delta P_{c_t}^e + \gamma_3 \Delta RP_{e_t} + \gamma_4 \Delta T_t + \omega \quad (10)$$

Where,

$$u_t = m_t - \beta_0 - \beta_1 y_t - \beta_2 P_c^e - \beta_3 RP_e - \beta_4 T_t \quad (11)$$

FM-OLS was used to estimate equation 9 with trend, which resulted in the coefficient of treasury bills being insignificant. The treasury bills variable was then removed and the model was estimated with a constant and deterministic trend (Table 2).

Table 2: Fully Modified OLS Estimates (equation 9) - Egypt

<i>Variable</i>	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-Statistic</i>	<i>Prob.</i>
<i>y</i>	0.411827	0.178738	2.304079	0.0264
<i>P_c^e</i>	0.851427	0.210694	4.041059	0.0002
<i>RP_e</i>	-0.047845	0.020649	-2.317039	0.0256
<i>C</i>	15.86990	4.752072	3.339575	0.0018
@TREND	0.020182	0.003637	5.549401	0.0000
R ² = 0.755687				

The estimate yields reasonable coefficients which are also significant, with a reasonably strong R-squared. The significant results of FM-OLS are reflected in the long run relationship estimates by Hansen (1992b). The results in Table 3 show that the L_c statistic is 0.482936 and that the null hypothesis of cointegration is not rejected at the 5 per cent level of significance.

Table3: Hansen Cointegration test - Egypt

<i>Lc statistic</i>	<i>Stochastic Trends (m)</i>	<i>Deterministic Trends (k)</i>	<i>Excluded Trends (p2)</i>	<i>Prob.*</i>
0.482936	3	1	0	> 0.2

Note: *Hansen (1992b) Lc(m2=3, k=1) p-values, where m2=m-p2 is the number of stochastic trends in the asymptotic distribution

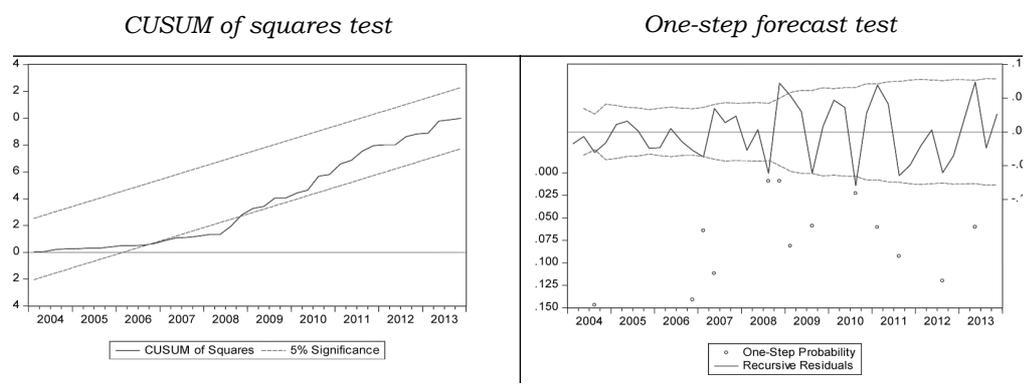
Table 4: Estimates of the ECM of demand for money (equation 10) - Egypt

<i>Variable</i>	<i>Coefficient</i>	<i>Standard error</i>	<i>t-statistic</i>	<i>Prob.*</i>
Δy_t	0.418089	0.318328	1.313392	0.1965
ΔP_c^e	0.957523	0.428253	2.235881	0.0310
ΔRP_{et}	-0.032627	0.057187	-0.570537	0.5715
u_{t-1}	-1.025362	0.166292	-6.166022	0.0000
<i>C</i>	0.022633	0.011080	2.042681	0.0477
R ² = 0.49; σ = 0.03				
DW = 2.02				

We then estimate equation 10, to examine the adjustments that take place to restore long run equilibrium of money demand, in response to short term disturbances. As expected, the results in Table 4 show that the error correction term is negative and significant, confirming the long run relation detected by the cointegration analysis. The negative sign on the error correction term indicates that money demand adjusts in the succeeding period in response to disequilibrium in money balances. The error correction model's error correction term ensures that the long run relationship established by the cointegration analysis holds in the steady state.

Moreover, recursive least squares tests are used to check the stability of the parameters reported in Table 4. The recursive residuals test uses the one-step-ahead forecast error resulting from the last estimate of b vector using k coefficients observations in succession.

Figure 1: The recursive residual tests - Egypt



According to the residuals recursive test, parameters are unstable when the residuals are outside the standard errors bands. The CUSUM of squares test is based on the cumulative sum of recursive residuals. In this test, parameters are stable if the CUSUM does not go outside the area between the two critical lines. Figure 1 shows the recursive residuals test and the CUSUM of squares test. Clearly, it shows instability in the parameters of the demand for money function in Egypt.

4.2. The stability of demand for money function in Iran during the period 1991-2007

Similar to Egypt, the long-run demand for money function in Iran incorporates the following variables:

$$m_t = \beta_0 + \beta_1 y_t + \beta_2 P_c^e + \beta_3 RP_e + \beta_4 D_t + \varepsilon_t \tag{12}$$

The variables in equation 12 are measured in a similar way to the case of Egypt, with some minor exceptions: (i) real income, y , is GDP with fixed prices (1997:Q1=100), (ii) the expected purchasing power of money in terms of prices

of goods and services, P_c^e , is the lagged value of P_c ($P_c^e = (P_c)_{t-1}$). P_c , the purchasing power of money in terms of prices of goods and services, is the inverse of GDP deflator, (iii) the price of a monetary unit spent on equities relative to the price of a monetary unit spent on goods and services, RP_e , is the ratio of GDP deflator divided by share-price index, i.e. $RP_e = \text{GDP deflator} / \text{share-price index}$, (iv) because quarterly data on *sukuk* (Islamic bonds) prices are not available the short-term deposit rate, D_i , is used as a proxy for the price of a monetary unit spent on *sukuk*. The expected signs of explanatory variables included in the equation 12 are β_2 and $\beta_3 > 0$, and β_4 , and $\beta_5 < 0$. All variables included in equation 12 are in logs and seasonally adjusted, except for short-term deposit rate, D_i .¹⁶

The unit-root tests (see Table 5) indicate that all variables are integrated of order one at the 5 per cent significance level, except for RP_e , which is integrated of order one at the 1 per cent significance level.

Table 5: ADF Test Results for Unit Roots - Iran

<i>Variable</i>	<i>Without trend</i>	<i>With trend</i>	<i>Lag length</i>
<i>RdM2</i>	-2.04*	-2.06*	(1)
<i>Y</i>	-2.10*	-1.95*	(3)
P_c^e	-2.41*	-1.89*	(0)
RP_e	-3.11**	-4.57	(2)
<i>D1</i>	-1.92*	-1.30*	(0)

Notes:

1. An asterisk indicates significance at the 5 per cent level
2. The lags of the dependent variable used to obtain a white-noise residuals are determined using AIC

FM-OLS was used to estimate equation 12 without trend, which resulted in the coefficient of RP_e being insignificant and the coefficient sign of Di being inconsistent with the expected sign. RP_e and Di were then removed and the model was estimated with a constant (Table 6).

Table 6: Fully Modified OLS Estimates - Iran

<i>Variable</i>	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-Statistic</i>	<i>Prob.</i>
<i>y</i>	1.268693	0.127767	9.929711	0.0000
P_c	0.138848	0.028325	4.901955	0.0000
<i>C</i>	29.04769	0.572680	50.72238	0.0000
R ² = 0.89				

The estimate, as in the case of Egypt, yields reasonable coefficients which are also significant with a very strong R-squared. The results of the FM-OLS estimation are also reflected in the long run cointegration relationship estimates of Hansen (1992b). The results in Table 7 show that the L_c statistic is 0.228416 and that the null hypothesis of cointegration is not rejected at 5 per cent level of significance.

L_c statistic	Stochastic Trends (m)	Deterministic Trends (k)	Excluded Trends (p2)	Prob.*
0.228416	2	0	0	> 0.2

Note: *Hansen (1992b) $L_c(m=2, k=0)$ p-values, where $m=2$ is the number of stochastic trends in the asymptotic distribution

We then turn to the estimates of equation 13, to examine the adjustments that take place to restore the long run equilibrium of the money demand in response to short term disturbances.

$$\Delta m_t = c_t + \lambda u_{t-1} + \gamma_1 \Delta y_t + \gamma_2 \Delta P_{c,t} + \omega \tag{13}$$

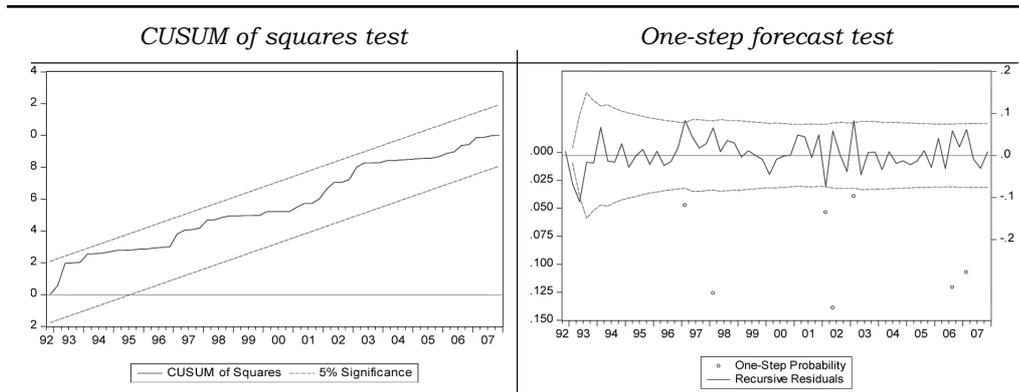
The results in Table 8 show that the error correction term is negative and also significant, as expected, which confirms the long run relationship detected by the Hansen (1992b) cointegration test.

Variable	Coefficient	Standard error	t-statistic	Prob.*
Δy_t	0.413511	0.171465	2.411638	0.0189
$\Delta P_{c,t}$	0.275023	0.129895	2.117266	0.0383
u_{t-1}	-0.350009	0.094613	-3.699396	0.0005
C	0.012274	0.008231	1.491255	0.1410
R ² = 0.22; σ = 0.03				
DW = 2.15				

In addition, Figure 2 shows the recursive residuals test and the CUSUM of squares test. Clearly, it does not detect instability in the parameter of the demand for money function in Iran.

To sum up, the findings at the 5 per cent level of significance are rather interesting in that they indicate that the income coefficient (income elasticity of money demand) in Iran (the impact value 1.26 - Table 6) is higher than for Egypt

Figure 2: The recursive residual tests - Iran



(the impact value 0.41 - Table 2). One possible explanation as to why the income coefficient in Iran is higher is the fact that, in Iran, economic agents engage in more Islamic financial transactions that comply with *Shariah*, which prohibits the use of some financial instruments (e.g. short and long term debt) present in conventional interest rate-based banking systems like in Egypt. Income elasticity of money demand has also implications for monetary policy conduct in both Egypt and Iran. How elastic money demand for change in income affects the stability of the demand for money and hence increasing the possibility of putting in place and implementing an effective monetary policy.

5. CONCLUSION

A stable demand for money enables central banks accurately to predict the demand for money and hence manage the money supply using monetary policy instruments, in order to achieve the primary goals of monetary policy, such as price stability. This paper examines the stability of demand for money function in a fully-fledged Islamic banking system and a conventional (interest-based) banking system. The paper adopts a restructured form of Friedman's (1956), model which considers real demand for money as an extension to the theory of demand for (durable) goods. Real demand for money is determined by real income, the price of money, the expected price of money, and the relative prices of other alternatives to money (bonds and equities).

In this study, the Iranian banking system is regarded as an Islamic banking system, and the Egyptian banking system as a conventional banking system. The stability of the demand for money function under the two systems has been investigated in two steps. Firstly, we estimate the long-run demand for money function. Secondly, we apply stability tests of the demand for money in the framework of ECM.

Based on the results of the statistical analysis, the study concludes that the demand for money function is stable under the Islamic banking system

and unstable under the interest-based banking system. However, the results of the statistical analysis should be interpreted cautiously, since it is limited to the cases considered by the study and the time horizon of each case. Generalising the above conclusion, however, should be based upon additional investigations in the countries that follow Islamic and non-Islamic banking systems.

The stability of demand for money is necessary for the effectiveness of monetary policy. The results presented in this paper provide evidence of the positive impact of an interest free monetary system on financial and economic stability. The findings are in line with Siddiqi's (1982) argument that the introduction of the profit sharing ratio to replace interest rates will not destabilise the economy. The findings should be of interest to both policy makers and monetary economists, as they provide further evidence of the potential role that the profit sharing ratio can play as a monetary policy tool to stabilise the demand for money function. Substituting the interest rate by the profit sharing ratio will not affect financial markets only, but will also result in significant changes in the real economy.

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ENDNOTES

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2. Alaa M. Soliman: Senior Lecturer in Economics, Leeds Beckett University, Faculty of Business and Law, 520-Rose Bowl, Leeds LS1 3HB, United Kingdom. Email: a.soliman@leedsbeckett.ac.uk
3. According to the IMF report (2013) on exchange arrangements and exchange restrictions, 26 adopt monetary aggregate targeting, and 34 countries adopt inflation-targeting framework. The de-facto classification sees the Central Bank of Egypt (CBE) and Central Bank of Sudan (CBOS) as conducting monetary policy based on no explicitly stated nominal anchor, whereas the Central Bank of the Islamic Republic of Iran (CBI) follows a composite exchange rate anchor, where the exchange rate serves as an intermediate target of monetary policy.
4. By generalising the standard IS-LM model to study the effect of monetary policy on macroeconomic variables in an Islamic economy, Khan and Mirakhor (1989) conclude that there is no fundamental change in the way monetary policy affects economic variables.
5. A *Mudarabah* (trust finance) contract meets short-run businesses where funds are provided by the Islamic bank to an investor, in return for a predetermined profit-shar-

ing ratio. If a loss is incurred, an Islamic bank bears it exclusively and the investor loses the reward for his/her time and effort. In contrast to *Mudarabah*, a *Musharakah* (joint venture finance) contract meets long-run businesses where an Islamic bank is engaged in a contractual relationship with equal or variable shares in an investment project. The distribution of profits is determined either upon agreement or upon the ratio of contribution of each part in the principal, whereas the losses are distributed upon the ratio of contribution of each part in the principal. It is important to distinguish between a *Mudarabah* investor who is considered an important stakeholder and a *Musharakah* investor who is considered a shareholder. In the case of bankruptcy, the *Mudarabah* investors will have a priority claim on the remaining assets, whereas *Musharakah* investors may lose their investments. Also, it is important to distinguish between *Musharakah* investors and equity investors, where the former receive dividends limited to a predetermined time period and profit ratio. In addition, *Musharakah* investment is less liquid than equity investment, since there is no trading in a *Musharakah* investment (Wilson, 2008).

6. Islamic central banks have plenty of monetary policy instruments that can be employed to manage monetary policy. For more details see Awad (2015).

7. It should be noted that the introduction of nominal interest rate, i , in the demand for money function as an explanatory variable would make it unstable, other things being equal. That can happen when the short-term nominal interest rate is used as a monetary policy instrument, or because of the deregulation of interest rates (Awad, 2010). In contrast, the use of commercial banks' profit-sharing ratio, g_b , as a monetary policy instrument does not necessarily destabilise the demand for money function when Islamic CB moves g_b , to offset undesirable movements in the expected rate of profits, R^e , i.e., the client's share in the expected return, α_c , as an explanatory variable in the demand for money function does not undergo high fluctuations.

8. The main reason that the description of the interest rate as the price of money is flawed is that it implies a simple relation between interest rate and money. That simple relationship between interest rate and money leads to the wrong belief that, for example, high interest rates are the results of a tight monetary policy by central banks. Money can be created by a central bank and then lent out to viable customers or investors. This will lead to an increase in the supply of loans, a reduction in the interest rate and an increase in the money supply. That is just one side of the story. What is affecting the interest rate is not the amount of money created by the central bank but the amount of loans granted in that money creation process. In that respect one could argue that a government could get the same effect by collecting more in taxes than it spends (e.g. running a budget surplus) and lending out the difference. The lending out of the budget surplus (e.g. the amount of loans granted to economic agents) affects the interest rate. The interest rate is the market price or the price paid for the use of capital. Central banks control interest rates in the same way an economic agent can control the price of a good or a commodity, by choosing to buy or sell some of it. The weak relationship between money and interest rates can be evidenced easily by the inability of the massive quantitative easing programmes (QE) in effectively lowering the rate of interest. It again goes back to the role that loans play in the process of money creation. The amount of loans that is influenced by many other microeconomic and macroeconomic factors, such as consumer and business confidence (i.e., inducing investment in the real sector) or labour market, plays an important role in determining the rates of interest.

9. Islamic bonds, or *sukuk*, represent an asset-backed paper with ownership claims on assets linked to investment. The face value of *sukuk* is based upon the market value of the underlying asset, where each *sukuk* represents a share in the asset. A *sukuk* holder receives a proportionate share in profits (or bears a proportionate share in losses). In contrast to conventional bonds, the *sukuk* holder may not get back the face value of *sukuk* at maturity because the market value of *sukuk* at maturity depends on the performance of the existing project. Most Shariah scholars believe that a promise by the issuer to repurchase *sukuk* with the face value at maturity date does contradict Islamic law.

10. Indeed we were seeking to investigate the stability of demand for money function in Sudan which instigated an Islamic banking system in the second half of the 1980s. Unfortunately, data on some variables in equation 7 are not available and some other data have breaks.

11. After the revolution in 1979, the Iranian government enacted a new law in 1983 that prohibited the payment or receipt of interest rates on banks' activities, except for the CBI's transactions with governmental and public institutions, and banks, as long as these institutions use their own resources. The new law came into effect on March 20th, 1984. Since then, banks have been allowed to pay a return on saving and time deposits based on their profitability (Hassani 2010).

12. IFS is Available at:

http://www.elibrary.imf.org/search?t100=urn:Series/041&type_0=booksandjournals&browsePage=series&sort=datedescending,

CBI database is available at:

<http://www.cbi.ir/page/8020.aspx>,

and CBE database is available at:

<http://www.cbe.org.eg/English/Statistics/>

13. Under the adaptive expectation hypothesis, expected inflation (π^*_t) takes the following form: $\pi^*_t = \pi^*_{t-1} + \gamma(\pi_{t-1} - \pi^*_{t-1})$ or, $\pi^*_t = \gamma\pi_{t-1} + (1-\gamma)\pi^*_{t-1}$. Under the assumption that the expectations factor (γ) = 1, or equivalently the expectations are instantaneously the lagged value of inflation, π^*_{t-1} , can be used as a measure of expected inflation.

14. The introduction of logarithmic form leads to the exclusion of P_c (= $100/CPI$) from money demand specification, since the variable P_c is reflected by RP_e (= $CPI/share-price\ index$).

15. The econometric use of the term 'equilibrium' indicates any long run relationship. Any equilibrium relationship among a set of non-stationary variables implies that their stochastic trends must be linked, i.e. the variables cannot move independently of each other. This linkage among stochastic trends necessitates that the variables be cointegrated. Although Engle and Granger's (1987) original definition of cointegration refers to variables that are integrated of the same order, it is possible to find equilibrium relationships among group of variables that are integrated of different orders. This case is known as 'multicointegration' (Enders 2004 pp 319-323).

16. Similar to Egypt, the introduction of the logarithm form leads to the exclusion of P_c (= $100/GDP\ deflator$) from money demand specification since the variable P_c is reflected by RP_e (= $GDP\ deflator/share-price\ index$).

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A problem with the course presentation of the single-price alternative to 3rd-degree price discrimination

Melvin Borland and Roy Howsen¹

ABSTRACT

The typical procedure for the determination of output, price, and profit associated with the single-price alternative to 3rd-degree price discrimination found in intermediate texts, managerial texts, and other texts concerned with pricing works well under certain specifications with respect to revenue and cost, but not all. It is oversimplified and, as such, unreliable for the determination of output, price, and profit, dependent on arbitrary, but specific, choices of values for the parameters of associated revenue and cost functions; and is, therefore, at least non-general. Suggestions for course presentation of the single-price alternative, given the reconsideration of the procedure for the determination of output, price, and profit and the computation of a discriminating critical value developed in this paper, are easily inferred. Illustrations are provided throughout.

1. INTRODUCTION

The benefit to a firm that engages in 3rd-degree price discrimination is often claimed to be made clear in course presentations by a comparison of results with respect to the output, price, and profit under price discrimination to such results associated with the single-price alternative to price discrimination. However, for the results associated with the single-price alternative to be appropriate for such a comparison in the establishment of the claimed benefit of 3rd-degree price discrimination, the results for the alternative must, of course, be reliable with respect to the profit-maximising levels of output, price, and profit under that alternative. In this regard, it is shown in this paper that the particular levels of output, price, and profit for the single-price alternative derived from the procedure typical of intermediate texts, managerial texts, and other texts concerned with pricing are unreliable, dependent on arbitrary, but specific choices of values for parameters of revenue and cost functions, and, therefore, at least non-general. See, for example, Baye (2006), Png and Lehman (2007), Keat and Young (2008), Hirschey (2009), Fisher *et al* (2010),

and Thomas and Maurice (2010). Suggestions for course presentation of the single-price alternative, given the reconsideration of the procedure for the determination of output, price, and profit and the computation of a discriminating critical value developed in this paper, are easily inferred. Illustrations are provided throughout.

There is a considerable literature with respect to the welfare consequences of 3rd-degree price discrimination, in general, both pro and con. This is so, in particular, with respect to the welfare consequences for consumers in relatively small markets not otherwise served under the single-price alternative to 3rd-price discrimination that provides insight for this reconsideration.² In a paper by Layson (1994), following the work of Battalio and Ekelund (1972) in which a geometrical analysis is provided, algebraic conditions are offered for the determination of whether or not consumers in small markets otherwise not served under the single-price alternative would, indeed, be served under 3rd-degree price discrimination. Nevertheless, although such a systematic consideration of the specific conditions under which price discrimination would include consumers not previously served exists in the literature, and is well done, and despite previous qualifications, it has long been thought in the specific case of independent demands and constant marginal costs that firm output is invariant to the application of 3rd-degree price discrimination.³

Recent literature⁴ that exists in particular with respect to course presentations of the consequences of the application of 3rd-degree price discrimination clearly indicates that the long-standing belief of invariance continues. The reconsidered method of solution for the levels of output, price, and profit presented in this paper for the single-price alternative, to which the results under price discrimination may be compared in a parameterised model, are indicated, below. Such a reconsidered method of solution is more thorough than the typical method of solution common to the various microeconomic texts.

2. INITIAL CONDITIONS AND STANDARD PRACTICE

In standard practice, to establish a basis for comparison, consider conditions in which the demands in markets, R and S, are given, for example, by specific, parameterised equations, such as:

$$p_r = 12 - 0.5 * q_r \quad (1)$$

and

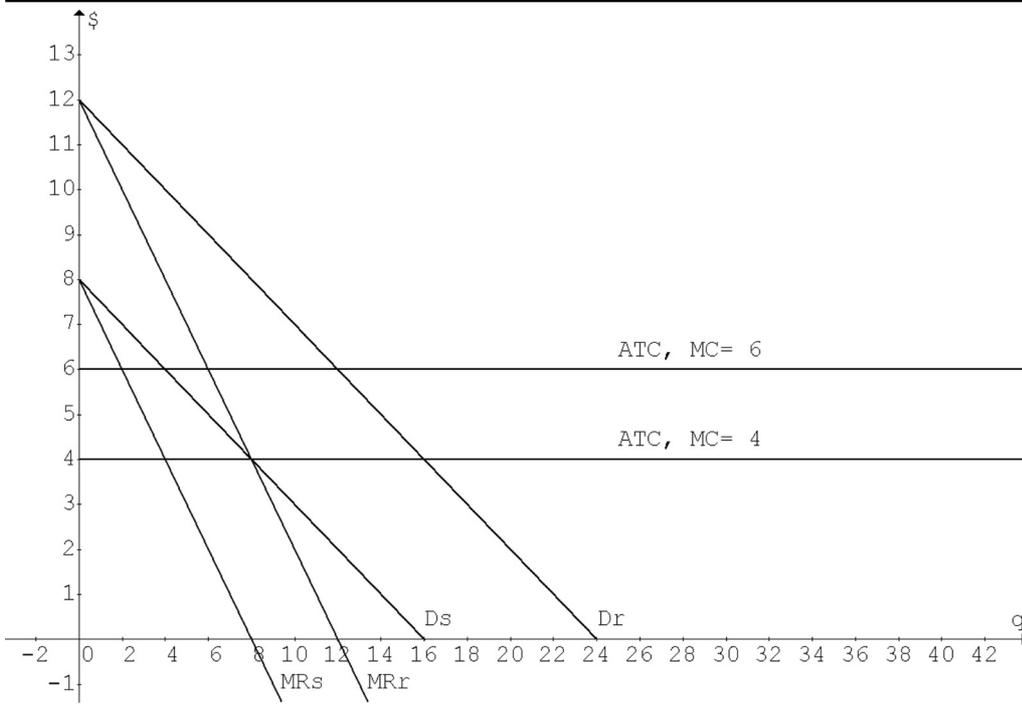
$$p_s = 8 - 0.5 * q_s \quad (2)$$

where p_r and p_s are prices per unit and q_r and q_s are individual market quantities in markets, R and S, respectively.⁵ For ease of exposition, let average and marginal cost be equal to a constant, K . As such, associated profit under 3rd-degree price discrimination, $\pi_{discrimination}$ is defined by the equation:

$$\pi_{discrimination} = pr * qr + ps * qs - K * (qr + qs) \quad (3)$$

See Figures 1, 2A and 2B for illustration. With respect to Figure 2A, a successful implementation of 3rd-degree price discrimination is shown to exist. Note the various solutions, described below.

Figure 1: Profit Maximisation in Individual Markets



For profit-maximisation under 3rd-degree price discrimination, the partial derivatives of the defined profit function with substitution:

$$\pi_{discrimination} = (12 - 0.5 * q_r) * q_r + (8 - 0.5 * q_s) * q_s - K * (q_r + q_s), \quad (4)$$

with respect to q_r and q_s , are set equal to zero and are as given below:

$$\partial \pi_{discrimination} / \partial q_r = 12 - q_r - K = 0 \quad (5)$$

and

$$\partial \pi_{discrimination} / \partial q_s = 8 - q_s - K = 0. \quad (6)$$

Solving:

$$q_r = 12 - K \quad (7)$$

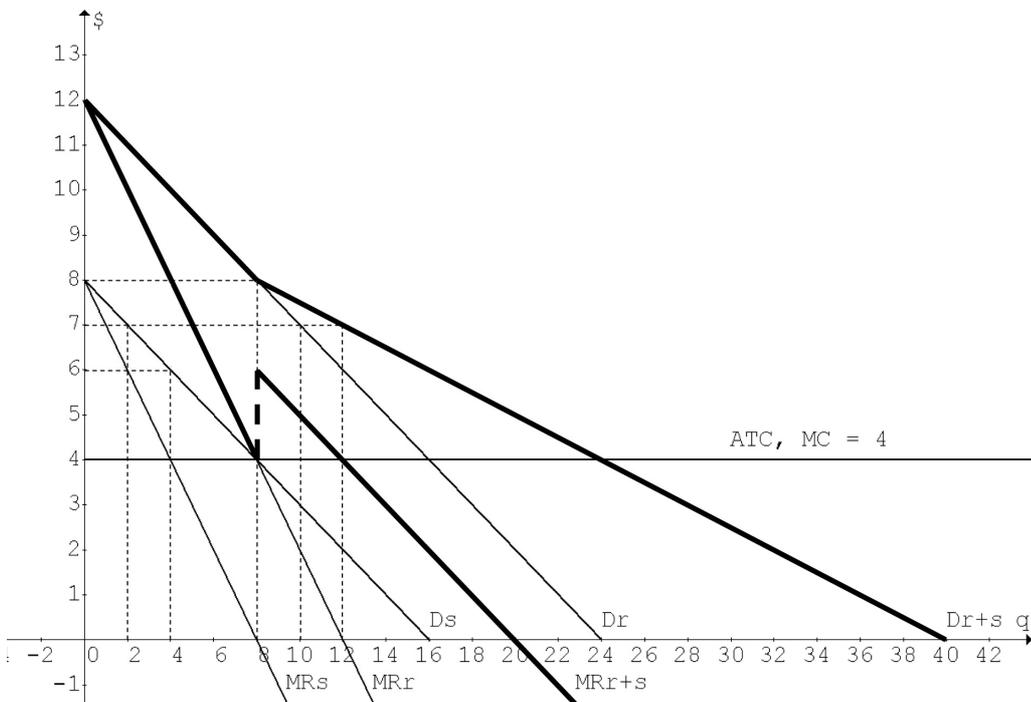
and

$$q_s = 8 - K, \tag{8}$$

provided that q_r and q_s are equal to or greater than 0. For example, where $K = 4$, then:

$q_r = 8$ and $q_s = 4$. Where $K = 6$, then $q_r = 6$ and $q_s = 2$.

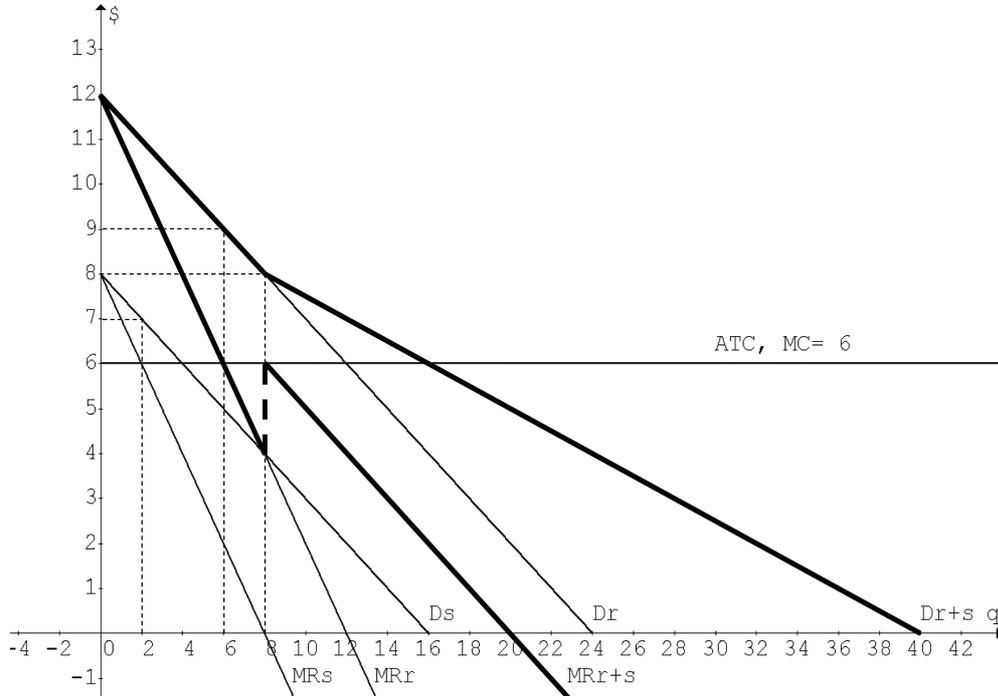
Figure 2a



Graphically, individual market demand curves and associated individual marginal revenue curves are, respectively, horizontally summed as indicated in Figures 2A and 2B, where ATC and MC are each equal to 4 and to 6, respectively. At the intersection of the marginal cost curve and the summed marginal revenue curve, MR_{r+s} , the total quantity of output is indicated. Individual market quantities are, then, determined by equating respective marginal revenue curves with marginal cost at the total quantity of output, previously specified. Prices are, then, determined by reference to individual demand curves at individual market quantities, respectively. Given the values for q_r and q_s , where $K = 4$, for example, $p_r = 8$ and $p_s = 6$. Where $K = 6$, then $p_r = 9$ and $p_s = 7$. Profit is computed as indicated, above, by equation (3). As such,

where $K = 4$, for example, $\pi_{discrimination} = 40$. Where $K = 6$, then $\pi_{discrimination} = 20$. Again, see Figures 2A and 2B for illustration.

Figure 2b



3. A PERFUNCTORY DESCRIPTION OF THE TYPICAL SINGLE-PRICE SOLUTION

For the typical single-price solution found in intermediate texts, managerial texts, and other texts concerned with pricing as an alternative to 3rd-degree price discrimination, where associated profit is represented by the symbol, $\pi_{typical\ single}$, profit is given by the expression:

$$\pi_{typical\ single} = (12 - 0.5 * q_r) * q_r + (8 - 0.5 * q_s) * q_s - K * (q_r + q_s). \quad (9)$$

The partial derivatives of the Lagrange-expressed profit function:

$$\begin{aligned} \pi_{typical\ single} = & (12 - 0.5 * q_r) * q_r + (8 - 0.5 * q_s) * q_s - K * (q_r + q_s) \\ & - \lambda * ((12 - 0.5 * q_r) - (8 - 0.5 * q_s)) \end{aligned} \quad (10)$$

with respect to q_r , q_s , and λ , the Lagrange multiplier, set equal to 0 are as given below:

$$\partial \pi_{typical\ single} / \partial q_r = 12 - q_r - K + \lambda * 0.5 = 0, \quad (11)$$

$$\pi_{\text{typical single}}/\partial q_s = 8 - q_s - K - \lambda * 0.5 = 0, \quad (12)$$

and

$$\pi_{\text{typical single}}/\partial \lambda = 12 - 0.5 * q_r - 8 + 0.5 * q_s = 0. \quad (13)$$

The Lagrange-expressed profit function, eq. (10), sets $\pi_{\text{typical single}}$ equal to the sum of revenues less total cost, as defined in eq. (9), and embodies the constraint that the prices in each market must be equal, that is, that $(12 - 0.5 * q_r) - (8 - 0.5 * q_s) = 0$. Solving:

$$q_r = 14 - K \quad (14)$$

and

$$q_s = 6 - K \quad (15)$$

provided that q_r and q_s are equal to or greater than 0. As such, where $K = 4$, for example:

$q_r = 10$ and $q_s = 2$. Where $K = 6$, then $q_r = 8$ and $q_s = 0$.

As indicated, above, individual market demand curves and associated individual marginal revenue curves are, respectively, horizontally summed, as indicated in Figures 2A and 2B. At the intersection of the marginal cost curve and the summed marginal revenue curve, the total quantity of output can be specified. The particular value of price for the single-price alternative to 3rd-degree price discrimination derived from this procedure common to the various microeconomic texts is then determined by reference to the summed demand curve, D_{r+s} , at the total quantity of output. Given the value for the sum of q_r and q_s , where $K = 4$, price in this single-price case is equal to 7. Where $K = 6$, price in this single-price case is equal to 8. See Figures 2A and 2B. Profit is computed as indicated, above, by equation (9). As such, where $K = 4$, for example, note that $\pi_{\text{typical single}} = 36$. Where $K = 6$, then note that: $\pi_{\text{typical single}} = 16$. Although this typical procedure often ends with such a result as if it is determinant and final, it is not necessarily thorough and complete. Consider a more thorough procedure and a substitute for the determination of the typical profit-maximising single-price solution, below.

3. A MORE THOROUGH SINGLE-PRICE METHOD OF SOLUTION AS AN ALTERNATIVE TO 3RD-DEGREE PRICE DISCRIMINATION

For the more thorough single-price method of solution as an alternative to 3rd-degree price discrimination, maximum profit is determined on the basis of a comparison of the level of profit associated with the typical method of solution, above, and the level of profit derived when one market only, that is, mar-

ket R in this example, is served. Associated profit is represented by the symbol, $\pi_{\text{typical single}}$. The derivative, and this is the important insight in this paper, set equal to 0, as a first consideration, of the one-market profit function:

$$\pi_{\text{alternative single}} = (12 - 0.5 * q_r) * q_r - K * q_r, \quad (16)$$

with respect to q_r , only, is as given below:

$$\partial \pi_{\text{alternative single}} / \partial q_r = 12 - q_r - K = 0. \quad (17)$$

Solving:

$$q_r = 12 - K, \quad (18)$$

provided that q_r is equal to or greater than 0. As such, where $K = 4$, for example, $q_r = 8$. Where $K = 6$, then $q_r = 6$.

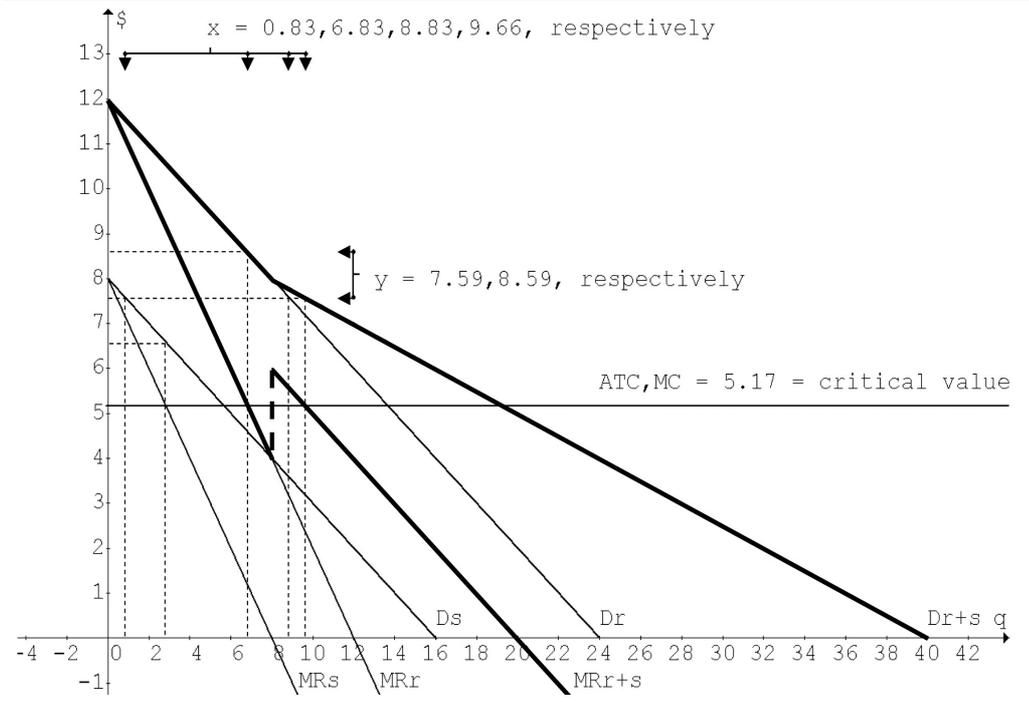
At the intersection of the marginal cost curve and the individual marginal revenue curve, MR_r, the total quantity of output is indicated. The particular value of price for the single-price alternative to 3rd-degree price discrimination derived from this first consideration of this more thorough method of solution is then determined by reference to the associated demand curve, D_r, at the total quantity of output. Given the value for q_r , where $K = 4$, price in this single-price case is equal to 8. Where $K = 6$, price in this single-price case is equal to 9. See Figures 2A and 2B. Profit is computed as indicated, above, by equation (9). As such, where $K = 4$, then:

$$\pi_{\text{alternative single}} = 32. \quad \text{Where } K = 6, \text{ then } \pi_{\text{alternative single}} = 18.$$

Note, therefore, that by comparison the typical single-price solution is shown to be unreliable as a measure of the level of maximum profit obtainable for a single-price alternative, in that respective values for the sum of q_r and q_s from the typical solution and for q_r , only, from the substitute solution, result in profits that are greater, i.e., $\pi_{\text{typical single}} = 36$ is greater than $\pi_{\text{alternative single}} = 32$, where $K = 4$, but less, i.e., $\pi_{\text{typical single}} = 16$ is less than $\pi_{\text{alternative single}} = 18$, where $K = 6$, than that associated with the substitute single-price solution dependent, of course, on the specific choice of values for the parameters of the cost function, i.e., for values of K , given demands for markets, R and S. As such, where $K = 4$, the typical single-price solution results in $\pi_{\text{typical single}} = 36$, a value greater than that associated with the alternative single-price solution that results in $\pi_{\text{typical single}} = 32$, at most. Where $K = 6$, however, $\pi_{\text{typical single}} = 16$ for the typical single-price solution, a value less than that associated with the substitute single-price solution that results in $\pi_{\text{alternative single}} = 18$, where q_r , only, is produced. As such, the typical single-price solution and the substitute single-price solution are alternatively unreliable with respect to the level of maximum profit, dependent on the arbitrary, but specific choice of values

for K for the cost function, given demands for markets, R and S, and, therefore, at least non-general. More generally, and as instruction for course presentation, where $\pi_{\text{typical single}}$ is greater than $\pi_{\text{alternative single}}$, take the typical single-price solution as the solution for the more thorough single-price solution. Where $\pi_{\text{typical single}}$ is less than $\pi_{\text{alternative single}}$, replace the typical single-price solution as the solution with the substitute single-price solution for the more thorough single-price solution.⁹

Figure 3



4. THE CRITICAL VALUE

Where the profit for the typical single-price solution is given by the equation:

$$\pi_{\text{typical single}} = K^2 - 20 * K + 100, \tag{19}$$

by substitution of equations (14) and (15) into equation (9), and the profit for the alternative single-price solution is given by the equation:

$$\pi_{\text{alternative single}} = 0.5 * K^2 - 12 * K + 72, \tag{20}$$

by substitution of equation (16) into equation (15), profits, respectively, are equal where:

$$K^2 - 20 * K + 100 = 0.5 * K^2 - 12 * K + 72 \text{ or, more conveniently, where:}$$

$$0.5 * K^2 - 8 * K + 28 = 0. \quad (21)$$

Solving the quadratic for the critical value for K :

$$K = 5.17.^{10} \quad (22)$$

With respect to the results of the single-price alternative to 3rd-degree price discrimination, profit for the typical single-price solution is greater than profit for the substitute single-price solution for values of average and marginal cost set near, but less than, 5.17: and less than profit for the substitute single-price solution for values of average and marginal cost set near, but greater than, 5.17. Profits are equal, of course, for average and marginal cost set equal to 5.17. As such, the textbook method of solution typically presented for the single-price alternative to price discrimination is, indeed, unreliable with respect to the determination of maximum profit for values for marginal cost set near, but greater than 5.17 for the example referenced above. The acceptability of the typical method of solution is, in general, sensitive to the choices of values for parameters of the revenue and cost functions for problems presented. Sometimes it is correct, sometimes it is not.

By observation of Figures 2A and 2B it is obvious, where average and marginal cost are greater than 6, but even less than 8, that the typical method of solution for single-price results is unreliable with respect to the level of maximum profit. The output and price results, i.e. $4 < q < 8$ and $10 > p > 8$, imply the relevance of market R, only, even though output is specified at the intersection of the marginal cost curve and the summed marginal revenue curve, MRs, under the typical method of solution. It is not obvious, however, where average and marginal cost are less than 6, but greater than 5.17, that the typical method of solution for single-price results is unreliable with respect to the level of maximum profit, even though it is, indeed, unreliable.

In the absence of knowledge of such a critical value of K , it is unreliable to present the typical single-price solution as a correct solution with respect to the determination of the level of firm output, price, and maximum profit. In such an absence, typical and substitute single-price solutions as alternatives to solutions under 3rd-degree price discrimination must otherwise, themselves, be compared as a first step of a more thorough method of solution. If $\pi_{\text{typical single}}$ is greater than $\pi_{\text{alternative single}}$ as a first step, then the typical method of solution is acceptable as an appropriate method of solution. If $\pi_{\text{typical single}}$ is less than $\pi_{\text{alternative single}}$ as a first consideration, then the typical method of solution is unacceptable as an appropriate method of solution. Under such a condition, the more thorough method of solution should be used as the reliable single-price alternative for comparison to the results under price discrimination. Although different texts consider different comparisons to the single-price alternative dependent on the number of markets served, that presumption about the number is premature to the arbitrary, but specific choice of values of parameters.

Therefore, even though a reliable solution can be computed in the absence of knowledge of such a critical value of K by comparisons as indicated above, knowledge of the critical value of K provides the opportunity for a direct and efficient determination of a reliable solution. For MC less than the critical value, use the typical method of solution. For MC greater than the critical value, use the substitute method of solution.

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ENDNOTES

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2. For example, see Smith and Formby (1981), Varian (1985), Stigler (1987), and Hausman and Mackie-Mason (1988).

3. Although there are, indeed, several degrees of price discrimination, the analysis in this paper is limited, of course, to 3rd degree price discrimination. In particular, see Smith and Formby (1981).

4. For example, see Carroll and Coates (1999), Jeitschko (2001), Kwon (2006), Round and McIver (2006) and Hirschey (2009).

5. Although the standard practice of parameterised equations has been followed, a generalised version will be made available as an electronic appendix on the journal website.

6. Many other parameterised equations for demands in the various markets may, of course, be considered. For such other parameterised equations, critical values, discussed later in this article, can be computed by analogy.

7. The horizontal summation of the marginal revenue curves is not required given that marginal cost is assumed in this paper to be equal to a constant, K . The quantity produced for sale to any one group does not affect the marginal cost of the quantity produced to any other group. Nevertheless, it is typical of texts to do so.

8. Total output under both price discrimination and the single-price alternative to price discrimination are typically observed to be equal. Justifications of this result are made by reference to the condition that marginal cost is equal under each pricing condition. This, too, is unreliable with respect to the level of maximum profit, dependent on arbi-

trary, but specific choices of values for parameters of revenue and cost functions and, also therefore, at least non-general.

9. Note that the typical single-price solution, unreliable for the determination of the level of output and maximum profit for the single-price alternative to which the results under price discrimination may be compared, is logically inconsistent with respect to the conditions for profit maximisation. Where $K = 6$ and q_r is set at 8, associated marginal revenue, MR_r , is less than marginal cost.

10. Extended, critical $K = 5.17157287525381$.

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Book Reviews

Marc Lavoie
Post-Keynesian Economics: New Foundations
Edward Elgar, 2014
ISBN:9781847204837

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This book, which is an updated and expanded version of *Foundations of Post-Keynesian Economic Analysis* that the author published in 1994, is a massive effort to present the work of Post-Keynesian economics in all fields. As such, it does not convey a single 'message', except perhaps that Post-Keynesian (PK) economics is alive and well and can serve as a complement and/or alternative to orthodox economic theory in all respects, starting from its methodological foundations.

This is particularly clear in the treatment of PK microeconomics, discussed in chapter 2 and 3. In contrast to the principles of optimising rationality, PK choice theory is characterised by fundamental uncertainty and bounded rationality. Similarly, rather than maximising profits, firms behave according to the principle of mark-up pricing, in line with the principle of 'realisticness', which Lavoie argues to be a central proposition of heterodox and PK economics.

PK economists have long argued that a 'monetary analysis' of the economy is a crucial starting point for economic theory. Lavoie does that in chapter 4, by starting his treatment of PK macroeconomics directly from the endogenous money theory. He reaffirms the 'horizontalist' position that central banks set interest rates and the supply of money is endogenously created by commercial banks, a view now shared to some extent by New Keynesian economists. Liquidity preference in this analysis plays a role in determining the differential between rates across financial markets. In fact, the 'horizontalist' position and liquidity-preference theory based on Tobin's portfolio choice approach, can be combined in the stock-flow consistent modelling approach, which is also discussed in the chapter. These views effectively apply without major differences to the open-economy, as chapter 7 makes clear: money remains endogenous and central banks retain their ability to set interest rates, regardless of the exchange rate regime.

Chapters 5 and 6 discuss economic activity, growth and unemployment. The central feature of PK economics in this field is that output and employ-

ment are demand-determined, in both the short and the long-run. Lavoie's analysis is largely based on the Kaleckian approach, and the key role that income distribution and capacity utilisation have in these models. The flexibility and success of the model is shown by the wide-ranging review that Lavoie gives to the several extensions to the basic model: e.g. technology, fluctuations and business cycles, finance, and open-economy considerations, which are discussed in the following chapter.

Aggregate demand determines output and employment, but not inflation, as discussed in chapter 8. Inflation is the result of unresolved conflict between workers and employers, but unlike for New Keynesians, lower unemployment will not automatically lead to higher inflation, and even less so to ever-accelerating inflation. Indeed, Lavoie argues that the Phillips' curve is flat at normal levels of capacity utilisation, so the main drivers of inflation will be in practice commodity prices, which unlike those of manufactured goods tend to rise in conditions of high global growth.

A strength of the book is to give an impartial overview of all strands of PK theory. According to his own classification, it would not be unreasonable to put Lavoie in the 'Kaleckian' strand on most issues. However, he always fairly describes the different positions and always seek to synthesise them in a coherent framework. This is clear, for example, in the treatment of exchange rates. The author adheres to Godley's view that current accounts are the crucial determinant of exchange movements in the long-run, but takes into account the 'fundamentalist' Keynesian argument of Harvey (2010) that expectations may play a role in the short-run, and incorporate such a view in his framework.

Overall, this is a wonderful and much needed 'encyclopaedia' of Post-Keynesian economics, that is likely become a standard reference in the future. It is by no means an introductory book, so undergraduate students or anyone else willing to approach PK economics for the first time could look at the introductory version of the book (Lavoie, 2009). But graduate students and academics who would like to strengthen their knowledge of Post-Keynesian economics, including for teaching purposes, would do well to read it.

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Wolfgang Streeck
Buying Time: The Delayed Crisis of Democratic Capitalism
Verso, 2014
ISBN: 9781781685488

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In this book, Streeck, a sociologist by training, constructs a provocative and powerful critique of neoliberal capitalism and the EU in its present form. Weaving together Marxist, Keynesian, and institutionalist ideas and concepts, *Buying Time* might remind readers of Varoufakis's *The Global Minotaur* (2011) or Patomäki's *The Great Eurozone Disaster* (2012), while nonetheless offering an original interpretation. Streeck's central thesis is that the history of Western capitalism since 1970 can be understood as a history of the revolt of capital against the social order of the 1950s-60s. Following a Polanyian (1944) 'laissez-faire is planned' line of argument, Streeck asserts that this revolt materialised into neoliberal policies, supported by governments 'buying time' for capitalism, through money illusion tactics: inflation, public debt, private debt spurred by financial liberalisation. Successful for a limited time, each of these eventually turned into hindrances to accumulation, needing to be transcended, always at the expense of the wage-dependent population.

The argument is presented over three main chapters. Chapter one combines a narrative of the current crisis as a triple crisis (of banking, public finances, and the real economy) with a critique of neo-Marxian Frankfurt School theories. The Golden Age of Capitalism, Frankfurt theorists believed, had created the preconditions for stable and prosperous growth, on account of the bargain struck between industrialists, trade unions, and governments, preventing further production crises, allowing only for legitimisation crises, if labour were to challenge this bargain. The main flaw in these theories, as identified by Streeck, is their failure to acknowledge capital as a class capable of strategic purpose, and to, therefore, recognise the possibility that capital, not labour, would cancel the postwar bargain.

Chapter two focuses on the debt crisis, analysed under a 'tragedy of the commons' framework. Mainstream explanations view public debt as a result of an extension of democratic politics to areas where it is not applicable, generating mass demands that exhaust the common pool of public finances. However, Streeck maintains that, if we are indeed facing a tragedy of the commons, this is because of the demands of capital, not labour. This is evidenced by the rise in inequality over the last decades, coinciding with tax cuts for the wealthy, and the observation that the steepest increase in public indebtedness occurred post-2008, after the rescue of too-big-to-fail financial institutions.

The debt state, chapter three argues, has altered the relationship

between capitalism and democracy, by instituting creditors, alongside voters, as a second constituency of contemporary governments, which has, since 2008, pushed for fiscal consolidation. Streeck goes on to present the evolution of the EU as a Hayekian project that prioritises market justice over social justice. This is followed by a warning that, if capitalist states fail to uphold at least an illusion of growth, democracy and capitalism must separate, with the most likely outcome being the finalisation of the Hayekian project. The opposite alternative, democracy without capitalism, would require nothing less than a complete reconfiguration of Western political economy.

Overall, *Buying Time* is a short, yet pithy and complex book, raising deep questions about the relationship between democracy and capitalism. By virtue of its emphasis on the inextricable links between history, economics, politics, and sociology, it appeals to a diverse, interdisciplinary audience. I particularly enjoyed the more subtle, secondary points Streeck makes, such as his recurring criticism of the Varieties of Capitalism literature as focusing unduly on the differences between capitalist countries and insufficiently on the parallels and interactions between them, as well as his observation that international political economy debates are largely insensitive to subnational dynamics, erroneously treating nations as homogeneous units.

Readers expecting an optimistic conclusion or quick solutions will be disappointed; the book is also not intended as an exhaustive or proportional discussion of the three interlocked crises—the debt crisis is given greater attention, whilst the banking crisis is described succinctly, without reference to the evolution of the originate-and-distribute model, for instance. For me, a minor point of criticism is that the author declares himself in favour of a European Bretton Woods, while being highly reproachful of the Gold Standard, seemingly unaware of the fallacies carried over from the latter to the former. This notwithstanding, *Buying Time* is an important and timely read for anyone concerned about the future of the EU and of democracy.

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Myles A Wickstead
Aid and Development: a Brief Introduction
Oxford University Press, 2015
ISBN: 978-0-19-874492-4

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Aid and Development deals with the following questions: how did the idea of development, and the role of aid in supporting it, evolve historically? And how was this evolution shaped by the economic and political environment?

As the institutions of international development reflect those ideas, the story of this institutionality is told over 7 chapters that compose the first part of the book, going from the Marshall Plan to the Millenium Development Goals (MDGs), and then from the G8 to the G20. The narrative is marked by catalytic events, each one triggering fundamental changes on how development was conceived and practiced, such as the end of the Second World War, the fall of the Berlin Wall and the 2008 global crisis. The second part works as an in-depth glossary for key terms.

Wickstead argues that within the Cold War logic, aid was a vital tool to recruit allies. The support that began targeting European countries was progressively extended to overseas programs. But because of the political framework, support also reached poor countries dominated by corrupted elites.

But the end of the Cold War made room for a more 'humanized' aid policy, where inveterate aid as a bargaining chip for political support was replaced by conditionalities to economic reforms and social inclusion. The Structural Adjustment Programs (SAPs) for example, prescribed for peripheral countries after the oil crisis in exchange for IMF's support, are portrayed as having a rescuer spirit, which deep down intended to 'stimulate growth and protect poor people' (p. 24) from corrupt local elites. The humanization process then is enshrined in the International Development Targets and the MDGs, which also include environmental issues in the agenda.

The author then goes on to argue that in our modern world aid played a diminished role, as the line that divides 'developed' from 'developing' countries gets blurred. This, according to him, became even more evident after the 2008 Crisis. His main policy prescription is that we should all get together in order to deal with mutual interests.

We propose an alternative narrative, which significantly differs from Wickstead's. Our version is based on the idea that the use of aid as an instrument to consolidate hegemonic power did not end with the fall of the Berlin Wall. It continues until today, although in a much less obvious way.

To start with, the US was not a distant observer who saw corrupted elites wasting precious resources, but whose hands were tied by the commu-

nist threat. The American support for military coups in Latin America is a good example of that. Those elites opened up the region to a model of modernization linked to foreign capital leadership, which paved the way to a form of domination based on technological and financial dependence (Martins, 2004). Whilst this model still had capacity 'to develop underdevelopment', the end of the Cold War and the neoliberal revolution give way to a more hostile domination, which started to be implemented through the SAPs.

Once the losers of the system multiplied, the World Bank and the IMF started to acknowledge that developing countries needed at least a basic form of social security (Chang, 2004) to give legitimacy to a system where inequalities are radicalized. Here lies the genesis of the humanization process addressed by the book. Although very much desirable, it ended up taking away the focus on the engines of development — change in the productive structure — vital for any real intention of catching up (Chang, 2013).

Lastly, the notion that the North-South divide does not exist anymore is very misleading. Although a semi-periphery has emerged (Arrighi, 1997) most semi-peripheral countries will never be promoted to the core. They exist because they play an economic role — they occupy a certain position in the global production chains — and a political role — their existence feeds the dream that one day everybody can get there. Therefore, the idea that these countries are equal enough to 'join the fight' is nothing more than a façade designed to exempt the core from the responsibility of addressing global issues mainly caused by them.

Wickstead's book deconstructs a common sense that instantly associates aid to trucks loaded with food in sub-Saharan Africa. The complexity of the subject is deployed in an accessible language. In my view though, it lacks a critical exposure of the ideologies that shaped aid policies throughout history.

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Marzenna Anna Weresa

Innovation, Human Capital and Trade Competitiveness. How Are They Connected and Why Do They Matter?

Springer, 2014

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This book analyses and evaluates relations of human capital and innovation with international competitiveness of economies at different levels of development. The authors employ the national innovation system (NIS) approach and Porter's concept of country competitive advantage in the conceptual and empirical analysis of these relationships. The main contribution of the book is to show that competitiveness, innovativeness and human capital variables are mutually dependent. The conceptual analysis shows that these three dimensions have different relationships based on the specific type of national innovation system and level of development of a country.

The book has two parts: theoretical and empirical. The first part (Ch 1-3) focuses on theoretical issues and methodology surrounding the analysis of relationships between international trade competitiveness, innovativeness and human capital. The second part (Ch 4-8) presents an econometric model and twelve selected country case studies of different types of NISs. The historical and descriptive data analysis presented in the twelve case studies clearly supports the conceptual method presented in the first part of the book. However, the econometric study presented in Chapter 4 does not provide very reliable or informative results. The book's concluding chapter proposes specific economic policy tools in order to support medium and long term competitiveness for different types of NISs. The conclusions and policy recommendations are specifically focused on developing countries like Poland, since human capital development is essential for them in order to adopt modern technologies and increase innovative capacity.

In my opinion, the econometric study presented in Chapter 4 may be viewed as the weakest point of the book. The analysis focuses too much on econometric techniques rather than the economic significance of the results. As a result, it is not entirely clear how the results relate to the conceptual analysis presented in the theoretical chapters. Given a lack of data description, it remains unclear which countries have been used for which period in the model. The authors claim that the econometric study confirms that the key characteristics and significance of individual factors of competitiveness depend on the type of national innovation system. However, only results for two out of four NIS types may lead to such conclusions. The authors admit that strong multicollinearity of independent variables for three out of four NISs may lead to instability of the model. Another weakness of the econometric

analysis is the decision to use different models for each group, which does not lead to comparable results. In my opinion a less complicated and single econometric technique for all NIS types may produce more reliable results.

Overall, I like the focus of the book on human capital as the key driver of innovation and competitiveness. Most literature analyses innovations as a simple input output process, but this book shows that innovation is a very complex process and having high R&D does not automatically lead to innovation. A country needs to develop human capital and supportive national innovation system to achieve international trade competitiveness. The authors clearly show that one size does not fit all. Each country needs to address their own specific problems. This book is best suited for economics students and professors. It may also be very useful for policy makers of developing countries interested in deeper understanding of human capital and innovation relations to international trade competitiveness.

Donal Donovan and Antoin E Murphy
The Fall of the Celtic Tiger: Ireland and the Euro Debt Crisis
Oxford University Press, 2013
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The fall of the Celtic Tiger traces the rise and downfall of the Irish economy and seeks to answer two related questions. First, on whose shoulders should responsibility for the crisis rest? Second, once the crisis began to unfold, were feasible policy alternatives available? It is thus part economic and part political analysis.

In 13 chapters the book's 300 pages are separated into four parts. The first section provides historical and theoretical background. This includes an overview of Irish economic history followed by a critique of Neoclassical Macroeconomics and the uncritical acceptance of Efficient Market Theory. Minsky and Keynes are offered as alternative paradigms.

The second part analyses the causes of the Irish crisis and focuses on financial practices and macroeconomic policy. It traces how deregulation and poor governance of the financial system led to the huge property bubble at the centre of Ireland's crisis. It documents the various policy initiatives and argues the core supervisory failures lay with the domestic central bank and financial regulator, with indirect responsibility at the European level. The analysis is succinct and comprehensive though an important omission is the growth of the Irish securitisation market.

Regarding macroeconomic policy, it shows that fiscal policy became severely unbalanced in its progressive reliance on windfall, bubble-related

taxes. This lay the foundation for a subsequent fiscal collapse. Pro-cyclical fiscal and monetary stances further inflated the property bubble, with Irish society largely acquiescent.

The invocation of alternative schools is welcome and the book successfully links Minskian theory with Irish banking practices with an impressive degree of clarity. Their contention of 'budgetary profligacy' (p115) is flawed and their evaluation of fiscal policy tendentious. The Irish state ran budgetary surpluses through most of the 2000s, so the charge of profligacy can be maintained only if it is assumed that policymakers identified a bubble, which they did not. Inexplicably, no blame is assigned to the ECB for its refusal to intervene in public debt markets.

The third and final substantive part deals with the crisis itself. Most important was the decision by the government in September 2008 to implement a blanket guarantee of the liabilities of the Irish banking system. For Donovan and Murphy this was justified as the reputational and financial costs of doing otherwise would have been catastrophic. The guarantee, they argue, was an inevitable result of the bubble and the imperative that no bank be allowed to fail.

This is highly contentious and seriously misreads policy alternatives. Other European countries intervened more cost effectively through, for instance, guaranteeing new debt only and initiating liquidation procedures (see Whelan, 2013). More, neither the option of renegeing on the guarantee nor leaving the euro is considered.

In allocating blame, while 'bankers' (and opinion makers) are repeatedly mentioned, their 'rational' behaviour is taken as given so that the broader population and domestic state structures are more often implicated. The complete ignoring of class divisions within and across borders allows much weaker societal categorisations into public vs private workers, domestic vs international agents, and so on. This facilitates conclusions such as 'few segments of the population failed to benefit significantly (from the boom)' (p141) while in reality though average incomes increased somewhat, top incomes increased much more rapidly (O'Connor and Staunton, 2015).

Overall, the book is well-written and documents the failures of the financial apparatus well. Its reading of macroeconomic policy and evaluation of policy alternatives is flawed and narrow. As a political work its allocation of responsibility on state failures and the broader population over financial actors is akin to blaming the police and community rather than those who perpetrated the crisis.

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