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ABSTRACT This paper examines the impact of outward FDI on domestic output and total factor productivity by applying cointegration techniques to macroeconomic time series data for Germany. We find a positive relationship between outward FDI and domestic output as well as between outward FDI and total factor productivity. Furthermore, our results indicate that there is bidirectional causality between outward FDI and domestic output, and outward FDI and total factor productivity, suggesting that increased output and productivity are both a consequence and a cause of increased outward FDI. Overall, the results of this paper can be interpreted as evidence of productivity-enhancing, and thus growth-enhancing, effects of outward FDI, which is inconsistent with the simplistic idea that outward investment represents a diversion of domestic economic activity.

KEY WORDS: Outward FDI, domestic production, total factor productivity, cointegration
JEL CLASSIFICATIONS: F23, F41, C22

1. Introduction

The question of whether and how outward foreign direct investment (FDI) affects domestic output has been the subject of extensive public debate in the industrialized world. Opponents of outward FDI argue that outward investment substitutes foreign for domestic production, thereby reducing total output and

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thus employment in the home (outward investing) country. Proponents of outward investment, in contrast, point out that outward FDI enables firms to enter new markets, to import intermediate goods from foreign affiliates at lower costs, and to access foreign technology. From this point of view, the entire domestic economy benefits from outward FDI due to the increased productivity of the investing companies and associated spillovers to local firms.

Surprisingly, there is little evidence concerning the potential macroeconomic consequences of outward FDI for the home countries. The empirical literature regarding outward FDI consists mainly of firm- and industry-level studies. Although these studies have certainly provided valuable insights into whether and how outward FDI may affect employment, exports, investment, and the productivity of outward investing firms and industries, they are, however, by definition, unable to account for the overall macroeconomic effects of outward FDI. Specifically, data restricted to individual investing firms or industries cannot capture possible spillover effects on the economy as a whole. In addition, most of these studies are based on firm- or industry-level data for manufacturing, thus necessarily excluding FDI in services from the analysis (the majority of FDI).

The objective of this paper is to examine the macroeconomic relationship between domestic output and total outward FDI. More precisely, we aim to investigate whether aggregate outward FDI affects total domestic output via changes in total factor productivity. To this end, we use a production function approach to estimate both the relationship between outward FDI and domestic output, and the relationship between outward investment and total factor productivity.

Specifically, we make the following contributions: first, given the problems inherent in cross-section and panel studies, such as endogeneity and cross-country heterogeneity, we use time series analysis for a single country. Second, we employ the concept of Granger causality to investigate whether changes in outward FDI lead to changes in output and productivity, or whether outward FDI is possibly also determined by domestic output and productivity. And third, as far as the empirical methodology is concerned, we use a battery of cointegration techniques, including system cointegration and single equation approaches, to examine both the short-run and the long-run effects of outward FDI on domestic productivity. To our knowledge, this is the first study to examine the short- and long-run macroeconomic effects of outward FDI on domestic output through productivity using cointegration and causality analysis for a single country – namely, for Germany.

Germany is an interesting case for several reasons. For one, Germany is among the largest outward FDI suppliers in the world, ranking third in terms of outward FDI stocks behind the US and the UK. Furthermore, according to UNCTAD data, foreign enterprise capital of German firms has grown faster in recent years than that of US and UK firms. And finally, in Germany there is an ongoing public policy debate concerning the high labor costs. Specifically, given that German firms may achieve major cost reductions by relocating activities to the low-wage countries of Central and Eastern Europe, the concern is that outward FDI replaces domestic production, thus reducing employment in Germany. Evidence that an increase in outward FDI leads to greater productivity and output would imply that this concern is unfounded.

To preview our main results, we find that outward FDI has a positive long-run effect on output and productivity, and that there is bidirectional causality between outward FDI and domestic output, and between outward FDI and total factor productivity. Thus, the results of this paper can be interpreted as evidence of productivity- and thus growth-enhancing effects of outward FDI, which is inconsistent with the simplistic notion that outward investment diverts resources away from domestic economic activity.

The rest of the paper is organized as follows. Section 2 discusses the productivity and output effects of outward investment in more detail and reviews the related empirical literature. Section 3 specifies the empirical models and describes the data used in the empirical analysis. The estimation results on the impact of outward FDI on domestic output and total factor productivity are presented in Sections 4 and 5, while Section 6 concludes.

2. Theoretical Background and Related Empirical Work

2.1 *Theoretical Background*

We begin our discussion of the productivity and output effects of outward FDI by considering possible interactions between domestic and foreign activities of multinational firms. To represent these interactions, suppose that the production function of a multinational firm is given by $Q = f(D, F, \theta_d, \theta_f)$, where Q is the representative firm's worldwide output, D is domestic input, F is foreign input, θ_d is a vector of factors that influence domestic production (such as domestic productivity), and θ_f represents factors that influence foreign production. Assuming that domestic input production is a function of domestic capital, $D(K_d)$, and that foreign input production is a function of foreign capital, $F(K_f)$, the first-order condition that characterizes the firm's profit-maximizing choice of domestic inputs is

$$\frac{\partial Q[D(K_d), F(K_f), \theta_d, \theta_f]}{\partial D(K_d)} = \lambda \tag{1}$$

where λ is total input cost – the firm's cost of capital. From equation (1) it can be seen that domestic and foreign production (or investment) of the multinational firm can be related either through the cost of capital, and thus through the financial side of the firm, if λ is somehow a function of F, or through the production process, if $\partial^2 Q[D(K_d), F(K_f), \theta_d, \theta_f]/\partial D(K_d)\partial F(K_f)$ is nonzero (see Desai *et al*., 2005).

Interactions between foreign and domestic activities operating through the financial side of the firm occur in a situation where fixed investments in different locations compete for funds due to costly external financing, as discussed in more detail by Stevens and Lipsey (1992). In such a scenario, the decision to invest scarce resources abroad inevitably reduces the likelihood of concurrent investments at home, implying that each dollar of outward FDI displaces a dollar of domestic investment. This substitution of domestic for foreign investment, in turn, is likely also to reduce domestic output and productivity. In particular, when the investments abroad come at the expense of investments necessary to sustain output and productivity at home (such as new machinery, worker training, and research and development (R&D)), outward FDI may reduce the domestic productivity and output of the investing firm in the long run.

Some studies, however, suggest that the situation of fixed resources appears to be rather atypical for multinational firms. Desai *et al*. (2004), for example, analyze how US multinationals capitalize affiliates around the world and find that US multinational affiliates substitute internal borrowing for costly external finance stemming from adverse capital market conditions. Similarly, Desai *et al*. (2008) show that US parents provide affiliates with additional equity to finance profitable investment opportunities during currency crises. Thus, as argued by Desai *et al*. (2005), possible interactions between domestic and foreign activities are less likely to occur through the financial side, but the production process acts as the main source of interdependence. Because of such interdependence, outward FDI can affect domestic productivity in several ways, each of which depends on the multinational firm's investment motive and the respective investment type. In the following, we distinguish three key types of investment: horizontal FDI, vertical FDI, and technology-sourcing FDI.

Horizontal or market-seeking FDI is motivated by market access and avoidance of trade frictions such as transport costs and import protection in the host country (for models of horizontal FDI, see Markusen, 1984; Horstmann & Markusen, 1987; and Markusen & Venables, 1998). The decision to engage in horizontal FDI is guided by the proximity-concentration tradeoff in which proximity to the host market avoids trade costs but incurs the added fixed cost of building a second production facility. FDI of this type thus occurs when a firm decides to serve foreign markets through local production, rather than exports, and hence to produce the same product or service in multiple countries. Consequently, horizontal FDI may substitute for exports of the goods that were previously produced in the investor's home country. This decrease in domestic export production, in turn, may be accompanied by a decrease in domestic productivity, since export intensity and firm productivity may be linked, as some studies suggest (see Castellani, 2002; Baldwin & Gu, 2003). However, the decline in output and productivity might only be a short-term phenomenon. The reason is because there is rarely a pure case of horizontal production in the sense that there is inevitably some vertical component to a firm, horizontal FDI can boost exports of intermediate goods and services from the home to the host country. For example, headquarters in the home country provide specialized services to foreign affiliates (such as R&D, design, marketing, finance, strategic management) even if the same final goods are produced in both the home and foreign country. Thus, in general terms, multinational firms combine home production with foreign production to increase their productivity and hence competitiveness both internationally and domestically (Desai *et al*., 2009). Furthermore, in the long run, horizontal FDI may allow the firm to raise its competitiveness through access to new markets or successful penetration of existing markets, thereby additionally increasing domestic productivity and thus output.

Vertical or efficiency-seeking FDI, in contrast, is driven by international factor price differences (for models of vertical FDI, see Helpman, 1984, and Helpman & Krugman, 1985). It takes place when a firm fragments its production process internationally, locating each stage of production in the country where it can be done at the lowest cost. Such relocations reduce domestic production, at least in the short run (as with horizontal FDI). However, in the longer run, vertical investment may allow the firm to import cheaper intermediate inputs from foreign affiliates and/or to produce a greater volume of final goods abroad at lower cost, thereby stimulating exports of intermediate goods used by foreign affiliates (Herzer, 2008). The new structure of the production chain may thus be associated with increased efficiency, and, as a result, the firm may be able to improve its competitive position, thus raising its domestic productivity over the long run. On the other hand, if the firm is not able to adjust over the longer term to the reduction in domestic production by failing to raise its competitiveness (e.g., due to labor market rigidities), both vertical and horizontal FDI will substitute foreign activities for domestic activities over the long run, which may also lead to a long-term decrease in domestic productivity (Bitzer & Görg, 2009).

Finally, technology-sourcing FDI occurs when firms attempt to gain access to foreign technology by either purchasing foreign firms or establishing R&D facilities in 'foreign centers of excellence' (for models of technology-sourcing FDI, see Neven & Siotis, 1996; Fosfuri & Motta, 1999; and Bjorvatn & Eckel, 2006). If foreign affiliates then acquire new knowledge in terms of technological know-how, management techniques, knowledge of consumer tastes, etc, this knowledge can be transferred back to the parent company, thus increasing domestic productivity in the long term (Van Pottelsberghe de la Potterie & Lichtenberg, 2001).

An important point is that outward FDI may not only affect the productivity of the investing firms, but also that of the economy as a whole through productivity spillovers to local firms. For example, local firms may improve their productivity by copying technologies used by domestic multinationals, or domestic producers may benefit from the knowledge and expertise of the outward-investing firms through labor turnover. Moreover, the increased competition between international firms and their domestically oriented counterparts may force the latter to use their existing resources more efficiently. Outward-investing firms, due to the increased productivity, may be also able to provide higher quality inputs at lower prices to local producers. In addition, if outward FDI allows the investing firms to grow larger than would be possible with production in just one country, both the investing companies and their local suppliers may benefit from economies of scale. Outward FDI may thus enable domestic suppliers to move down their learning curves and, therefore, to realize substantial productivity gains.

Because, however, FDI may act as an important vehicle for the transfer of technological and managerial know-how, it is likely to increase the competitiveness of the host economy as well. This may lead to reductions in domestic output and productivity when domestic consumers prefer the foreign competitors. Furthermore, the increased competitiveness may allow domestic firms in the host country to challenge the foreign firms and thereby to capture market shares from the foreign affiliates of the home country's multinationals. Outward FDI may therefore enable competitors in the host country to attract demand away from the home country firms, forcing them to reduce their production and to move up their average cost curve, resulting in productivity losses in the home country.

Thus, the net effect of outward FDI on aggregate productivity and output is theoretically ambiguous and must be determined empirically. While several studies exist on the firm- and industry-level effects of outward FDI on domestic productivity, there are, however, very few studies on the macroeconomics effects of outward FDI on domestic output and productivity.

2.2 *Empirical Literature*

Van Pottelsberghe de la Potterie and Lichtenberg (2001) use country-level macro data for a panel of 13 developed countries over the period 1971–1990 to examine specifically whether technology-sourcing FDI affects domestic productivity through foreign R&D spillovers. They find a positive long-run relationship between the foreign R&D capital stock weighted by outward FDI and domestic total factor productivity, implying that outward FDI into R&D-intensive countries indeed has beneficial effects upon home-country productivity by transferring technological knowledge from the host country. Bitzer and Kerekes (2008), however, reach a different conclusion. Their findings, based on industry-level data for 17 OECD countries between 1973 and 2000, suggest that the interaction between foreign R&D capital and outward FDI is negatively associated with domestic productivity in non-G7 countries; for the G7 the evidence of R&D spillovers through outward FDI is not significant. Both studies investigate 'only' whether outward FDI into major R&D-performing countries acts as a channel for R&D spillovers, thus neglecting all other potential productivity effects of outward FDI.

Braconier *et al.* (2001), in contrast, investigate both the effect of the outward-FDI-weighted foreign R&D capital stock and the effect of 'pure' outward FDI on domestic productivity. Using firm- and industry-level data for Sweden over the period 1978–1994, they find neither evidence of FDI-related R&D spillovers, nor any correlation between outward FDI per se and domestic productivity for Sweden. These results differ from those of Driffield *et al.* (2009). In an industry study for the UK covering the period 1978–1994, the authors distinguish between outward FDI in high-cost, high-R&D-intensive and outward FDI in low-cost, low-R&D-intensive countries. They find that both types of FDI generate productivity growth in the UK, suggesting that technology-sourcing and efficiency-seeking FDI increase domestic productivity. A similar result is obtained by Driffield and Chiang (2009), who investigate the effects of outward FDI from Taiwan to China. Based on industry data for 1995–2005, they report a positive association between outward FDI to China and labor productivity in Taiwan. Given the fact that labor costs in Taiwan are significantly above those in China, the authors conclude that this productivity effect is due to vertical (efficiency-seeking) FDI. Vahter and Masso (2007), on the other hand, use firm-level panel data from Estonia between 1995 and 2002 to examine the effects of outward FDI on total factor productivity of the investing firms and the rest of the industry. They find that outward FDI is positively related to the productivity of the parent companies, whereas there is no robust evidence of productivity spillovers to other firms. Since the overwhelming majority of FDI by Estonian firms is horizontal (market-seeking) (see Masso *et al.*, 2008), the positive productivity effects of Estonian outward FDI appear to be primarily associated with this type of FDI.

In another study, Kimura and Kiyota (2006) analyze Japanese firm-level data for the period 1994–2000. One of their findings is that outward FDI increases firm productivity. More specifically, their results suggest that firms engaging in outward FDI experience, on average, productivity growth 1.8 % higher than domestic firms not engaging in outward FDI. Hijzen *et al*. (2007), however, criticize this study for failing to control for the endogeneity bias that arises when more productive firms self-select into investing abroad. To deal with this endogeneity problem, they apply matching and difference-in-differences analysis to data of Japanese firms for the period 1995–2002. The evidence in their study suggests that the effect of outward FDI on Japanese firm productivity is not significant, whereas outward FDI has a positive and significant effect on firm output.

Propensity score matching and difference-in-difference techniques are also used in other studies. Barba Navaretti and Castellani (2004), for example, apply these methods to Italian firm-level data for the period 1973–1991. They find that multinational firms have higher total factor productivity and output growth after investing abroad than does a counterfactual of national firms. Hijzen *et al*. (2006), using French firm-level data between 1984 and 2002, report that firms that invest in developed countries increase their productivity, while firms that invest in developing countries experience no productivity effects, which could suggest that productivity effects of outward FDI are primarily associated with horizontal investment rather than vertical investment. Barba Navaretti *et al*. (2010) obtain the same result in a sample of French firms in the period 1993–2000; for Italy, however, they find exactly the opposite pattern: firms that invest in developing countries experience an increase in total factor productivity, whereas FDI into developed countries has no productivity effects.

Bitzer and Görg (2009) examine the effect of outward FDI on domestic total factor productivity using industry-level panel data for 17 OECD countries over the period 1973–2001. Their results suggest that outward FDI has, on average, a negative effect on total factor productivity, but that there are large differences across countries. Herzer (2010), in contrast, uses country-level panel data to investigate the long-run relationship between outward FDI and total factor productivity for a sample of 33 developing countries over the period 1980–2005. He finds a positive long-run relationship between outward FDI and total factor productivity in developing countries. He also finds that increased factor productivity is both a consequence and a cause of increased outward FDI, and that there are large cross-country differences in the long-run effects of outward FDI on total factor productivity.

The study by Herzer (2008) addresses the long-run relationship between outward FDI and domestic output (rather than productivity). His results, based on country-level panel data for 14 industrialized countries over the period 1971–2005, suggest that outward FDI has a positive long-run effect on domestic output, and that long-run causality runs in both directions; an increase in outward FDI increases domestic output and higher output, in turn, leads to higher FDI outflows.

Finally, as far as the evidence for Germany is concerned, Temouri *et al*. (2010), using firm-level data over the period 1997–2006, find that the productivity effects of outward FDI are positive, both for low and high cost countries. Kleinert and

Toubal (2007), in an analysis of German firm-level data for years 1997–2003, find no significant effect from the establishment of a foreign affiliate on firm productivity growth. Wagner (2009) examines the question of the firm-level effects of relocating production facilities abroad, often referred to as offshoring (see Görg *et al.*, 2008). His results indicate that more productive firms self-select into offshoring and that, in turn, offshoring leads to higher firm productivity. Although the study by Wagner does not distinguish between offshoring through vertical FDI (relocation abroad within the firm) and offshoring through subcontracting (relocation abroad between firms), this could suggest bidirectional causality between domestic productivity and vertical outward FDI.

Given these mixed results, perhaps the only conclusions that can safely be drawn from these studies are that outward FDI can have positive, as well as negative, effects on domestic productivity and domestic output, that the domestic output and productivity effects of outward FDI do not necessarily depend on the investment motive, and that the effects of outward FDI can differ significantly from country to country.

3. The Empirical Models and the Data

The empirical analysis will examine the aggregate effects of outward FDI on output and productivity in Germany. In this section, we specify the models used in the empirical analysis, discuss some econometric issues, and describe the data.

3.1 *Models*

We start with a Cobb-Douglas production function of the form

$$Y_t = A_t L_t^a K_t^b \tag{2}$$

where t is the time index, Y_t denotes output, A_t is a technology parameter representing total factor productivity, L_t stands for labor input, K_t denotes the capital stock, and a and b are the elasticities of production with respect to L_t and K_t, respectively. Since our objective is to investigate whether outward FDI affects domestic output via changes in total factor productivity, we assume the following relationship:

$$A_t = OFDI_t^{\delta} C E_t \tag{3}$$

where the constant C and the random variable E_t represent the productivity effects of all factors not explicitly considered in the model, and $OFDI_t$ is outward FDI. Following common practice, we use outward FDI stocks rather than outward FDI flows because stocks, due to the accumulation of flows, may more effectively capture long-run effects (see Bitzer & Görg, 2009; Herzer, 2010). Substitution of equation (3) into equation (2) and taking logs (ln) gives the regression equation

$$\ln Y_t = c + a \ln L_t + b \ln K_t + \delta \ln OFDI_t + e_t \tag{4}$$

where δ is the elasticity of total factor productivity and thus output with respect to $OFDI_t$, c is a constant, and e_t represents the usual error term. Equation (4) is the basic model we estimate. According to this equation, we cannot reject the hypothesis that domestic output is increased due to productivity gains induced by outward FDI if the estimate of δ is positive and statistically significant. Note that we do not restrict $(a + b)$ equal to one here, thus allowing for the possibility of non-constant returns to scale.

Alternatively, the aggregate productivity effects of outward FDI can be evaluated as follows: analogous to the growth accounting literature, we assume constant returns by imposing on equation (2) values of a and b derived from data on factor shares. Consequently, δ can be estimated using the logarithmic transformation of equation (3):

$$\ln A_t = c + \delta \ln F_t + e_t \tag{5}$$

where total factor productivity is defined (in the usual way) as $\ln A_t = \ln Y_t - a \ln L_t - b \ln K_t$ with a as the labor share of income and $b = (1 - a)$ as the capital share of income. Equation (5) is the second model used for estimation. However, it should be mentioned that equation (5) yields unbiased estimates of δ if production exhibits constant returns to scale. Thus, before estimating equation (5), it is useful to test for constant returns to scale using equation (4), $a + b = 1$. If the hypothesis of constant returns cannot be rejected and estimation of equation (4) yields values for a and b that are not significantly different from the factor shares, then the estimates of δ obtained from equations (5) and (4) should also not differ significantly.

Another important point is that equations (4) and (5) implicitly assume that outward FDI is exogenous in the sense that changes in outward FDI cause changes in aggregate output and total factor productivity. However, causality may also run from output and total factor productivity to outward FDI. The rationale for this is that recent firm-heterogeneity models, such as Helpman *et al.* (2004) and Antràs and Helpman (2004),[1] suggest that the establishment or acquisition of foreign affiliates involves additional costs of overcoming legal, cultural, and social barriers (sunk costs to investing abroad), so that only firms above a certain productivity threshold can cope with these fixed costs and thus engage in outward FDI. That is, only the most productive firms self-select into investing abroad.[2] Since an increase in aggregate productivity is generally associated with an increase in average firm

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[1]One of the first and most influential papers in this literature is Melitz (2003). He provides a convenient framework for the modeling of firm-level decisions in an open economy environment where heterogeneous firms self-select into different types of activities. This framework has been used to explain why only a fraction of firms choose to become multinationals and operate foreign affiliates (horizontal FDI) as in Helpman *et al.* (2004) or integrate with their foreign suppliers (vertical FDI) as in Antràs and Helpman (2004). Helpman *et al.* (2004) and Antràs and Helpman (2004) thus present the theoretical counterparts for respectively horizontal and vertical FDI. An extensive review of the related models is provided by Helpman (2006).

[2]Models of firm heterogeneity typically predict a productivity ranking in which foreign investing firms are the most productive, followed by exporters and non-exporters. This is confirmed by empirical evidence, which shows that multinationals are the most productive among the three types of firms (see Head & Ries (2003) for Japan, Girma *et al.* (2004) for Ireland, Arnold & Hussinger (2005) for Germany, and Girma *et al.* (2005) for the UK). Especially worth mentioning is the study by Tomiura (2007) which provides an extensive analysis of productivity differences across the entire range of internationalization options (in a cross-section of Japanese manufacturing firms).

productivity and, consequently, with an increase in the number of firms reaching the critical productivity level necessary for FDI, a macroeconomic implication of heterogeneous-firm models is that the aggregate amount of outward FDI should increase as aggregate output and total factor productivity increase. On the other hand, as argued by Herzer (2010), given that total factor productivity growth is generally associated with domestic output growth and higher demand, and therefore, better profit opportunities for domestic investment, an increase in productivity and output can also lead to a reallocation of scarce funds to more profitable domestic investment opportunities in place of less profitable outward investment. Consequently, increased output and productivity may be the cause of both reduced and increased outward FDI activity. The empirical implication is that it is important to deal with this potential endogeneity problem and to investigate the direction of causality.

3.2 *Data*

We now briefly describe the data used to estimate the equations: output, Y_t, is measured by German real GDP (in 2000 US$), while L_t is represented by the labor force (the number of people of working age, defined as being from 15 to 64 years old). Without question, a better measure of labor input would be employment times average hours, but reliable data on employment and hours worked are not available over a long enough period of time; there are data on employment for Germany as a whole only for the period after German unification (from 1991 onwards). Therefore, we follow the common practice of growth accounting studies and use instead the labor force as our measure of labor input (see Abu-Qarn & Abu-Bader, 2007). Given that official capital stock data are also available only for the post-unification period, we are forced to construct the physical capital stock from real investment data (gross capital formation in 2000 US$) using the perpetual inventory equation $K_t = I_t + (1 - \delta)K_{t-1}$, where I_t is investment and δ is the depreciation rate. Consistent with the literature, we set the initial value of the capital stock equal to $K_0 = I_0/(g + \delta)$,[3] where I_0 is the value of the investment series the first year it is available (1971), and g is the average growth rate of the investment series between the first year with available data and the first year of the estimation period (see Caselli, 2005). As is standard in the literature, a depreciation rate of 6% is assumed. Data on GDP, labor force, and gross capital formation are from the World Development Indicators (WDI) online database.

The calculation of total factor productivity, A_t, requires data on factor income shares. For the unified Germany, these data are also available as of 1991. On the other hand, the data released by the European Commission indicate that the wage

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He shows that firms engaged in outward FDI or in several internationalization modes are more productive than firms that outsource only and firms that export only.

[3]The rational for this choice is that $I/(g + \delta)$ is the expression for the capital stock in the steady state of the Solow model.

shares for Germany as a whole are relatively stable for the period after unification – around a value of 0.65. We therefore compute total factor productivity according to $\ln A_t = \ln Y_t - 0.65 \ln L_t - 0,35 \ln K_t$, as is common practice in the literature.

Data on the German outward FDI stock, $OFDI_t$, are from the UNCTAD FDI database (http://www.unctad.org/templates/Page.asp?IntItemID = 3277&lang = 1). UNCTAD defines *FDI* as 'an investment involving a long-term relationship and reflecting lasting interest and control of a resident entity in one economy in an enterprise resident in an economy other than that of the foreign direct investor' (UNCTAD, 2009). The *stock of FDI* is defined as 'the value of the share of the foreign enterprise capital and reserves (including retained profits) attributable to the parent enterprise plus the net indebtedness of affiliates to the parent enterprise'. Since UNCTAD reports outward FDI stocks as shares of GDP, we multiply the outward FDI-to-GDP ratio by real GDP (from the WDI) to construct real outward FDI stocks (in 2000 US$). Given that the UNCTAD data are first available for 1980, while both the WDI and the UNCTAD data end in 2008, the empirical analysis covers the period from 1980 to 2008.

In our view, this is sufficient to capture the long-run productivity effect of outward FDI. However, it should be mentioned that the behavior of the estimators and test statistics we use may be affected by the small sample size (29 time series observations). To deal with this problem, we will use small sample corrections whenever possible. In addition, we will use several estimation methods to ensure the robustness of our results. Moreover, we can easily check whether the estimates are seriously biased by using equations (4) and (5). As discussed above, if there is no bias (and our assumptions are correct), then – in the case of constant returns to scale – the estimates of equations (4) and (5) should produce approximately the same values for δ.

4. Econometric Results: Production Function Estimates

The pre-tests for unit roots, which are reported in Table A1 in the Appendix, suggest that the variables are integrated of order one, I(1). This section tests for cointegration between $\ln Y_t$, $\ln L_t$, $\ln K_t$, and $\ln OFDI_t$, and provides estimates of the parameters of the augmented production function given by equation (4). Specifically, we use the Johansen (1995) system cointegration approach to test for cointegration, long-run exclusion and weak exogeneity (long-run causality) as well as to estimate the parameters of our production function.

The Johansen approach is based on reformulating an n-dimensional and pth-order vector (y_t) to a vector error correction model (VECM):

$$\Delta y_t = \mu + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-k} + \Pi y_{t-1} + \varepsilon_t \tag{6}$$

where $y_t = [\ln Y_t, \ln L_t, \ln K_t, \ln OFDI_t]'$ is a 4×1 vector of (potentially) endogenous variables, Γ_i is a 4×4 matrix of short-run coefficients, Π is a 4×4 matrix of long-run parameters, μ represents a 4×1 vector of constants, and ε_t is a 4×1 vector of white noise disturbances. If the data cointegrate, Π must be of reduced rank, $r < n$, with r as the number of distinct cointegrating vectors, such that $\Pi = \alpha\beta'$, where the matrices α and β contain the adjustment parameters and the cointegrating vectors, respectively.

We use three test statistics to determine the number of cointegrating vectors: the trace statistics, the maximum eigenvalue statistics, and the Schwarz criterion. The trace statistic tests the null hypothesis that the number of distinct cointegration vectors is less than or equal to r against the general alternative of n cointegrating vectors and it is expressed as

$$TR = T \sum_{i=r+1}^{n} \ln(1 - \lambda_i) \quad (7)$$

where $\lambda_{r+1}, \ldots, \lambda_n$ are the $n - r$ smallest squared canonical correlations between y_{t-p} and Δy_t series corrected for the effect of the lagged difference of the y_t process. Furthermore, the maximum-eigenvalue test for testing at most r cointegration vectors against the alternative of $r + 1$ cointegration vectors is given by

$$\lambda \max = T \ln(1 - \lambda_{r+1}) \quad (8)$$

Both test statistics are adjusted by the small sample correction factor proposed by Reinsel and Ahn (1992), $(T - p \times k)/T$, to account for the small sample size.

Since the determination of cointegration rank is essentially a model specification problem, we also use the Schwarz model selection criterion (SC) to determine the number of cointegrating vectors. The Schwarz criterion has been shown to perform as well as (and sometimes better than) the trace and maximum eigenvalue tests and is computed according to the following equation (see Wang & Bessler, 2005):

$$SC = \ln(\det(\hat{\Sigma})) + J \ln(T)/T \quad (9)$$

where $\hat{\Sigma}$ is the maximum likelihood estimator of the variance-covariance Σ of the innovation (ε_t) with given lag order p and cointegration rank r, and J is the number of free parameters in the model, which increases with p and r. Because all standard lag selection criteria unanimously select a one-lag model, we calculate SC values for $r = 0, 1, 2, 3$ conditional on $p - 1 = 1$. Moreover, a 'reunification' dummy, $i91$, is included to account for an outlier in 1991, the year after the German reunification ($i91$ is 1 in 1991 and 0 elsewhere). Table 1 reports the results. Both the trace and maximum-eigenvalue and statistics strongly suggest that $\ln Y_t$, $\ln L_t$, $\ln K_t$, and $\ln OFDI_t$ are cointegrated and exhibit a single cointegrating vector. This finding is supported by the Schwarz criterion, which has a minimum value at $r = 1$.

We thus impose one cointegrating relationship, $r = 1$, on equation (4) and proceed with testing for long-run exclusion and weak exogeneity of the variables. The test of long-run exclusion investigates whether any of the variables can be excluded from the cointegration space, implying no long-run relationship with the remaining variables. It is formulated as a zero row of β, i.e. $H^i_\beta : \beta = 0$, where H^i_β is the hypothesis that the variable y_i, $i = 1, \ldots 4$, does not enter the cointegration

Table 1. Determination of the cointegration rank

	SC	Trace statistics	λ_{max}-statistics
$r = 0$	−19.350	90.91*** (54.46 / 47.21)	50.13*** (32.24 / 27.07)
1	−20.348	27.34 (35.65 / 29.68)	19.97 (25.52 / 20.97)
2	−20.001	12.01 (20.04 / 15.41)	11.96 (18.63 / 14.07)
3	−19.437	3.70 (6.65 / 3.76)	3.70 (6.65 / 3.76)

Note: The relevant 1% / 5% critical values (from Osterwald-Lenum, 1992) are in parentheses. The *** indicate a rejection at the 1% level. The model includes an unrestricted constant.

space. The test of weak exogeneity, in contrast, investigates the absence of long-run feedback and is formulated as a zero row of α, i.e. the hypothesis that the variable y_i, $i = 1, \ldots, 4$, does not adjust to the equilibrium error(s) represented by the cointegration relation(s). A significant adjustment coefficient suggests long-run endogeneity, and thus long-run Granger causality, whereas a non-significant α implies long-run Granger non-causality from the independent to the dependent variable(s), as well as weak exogeneity (Hall & Milne, 1994). Table 2 presents the results.

The results of the long-run exclusion tests show that none of the variables can be excluded from the long-run relation. Thus, all variables considered in the present study are relevant for modeling the long-run relationship, and hence any other model based on a subset of these variables will suffer from omitted variables bias. Furthermore, the weak exogeneity tests indicate that $\ln L_t$,and $\ln K_t$ can be regarded as weakly exogenous, whereas weak exogeneity of the output variable, $\ln Y_t$, and the FDI variable, $\ln OFDI_t$, is rejected. Consequently, both output and outward FDI are endogenous in the cointegrating relation, implying that the long-run causality between domestic output and outward FDI runs in both directions; this is consistent with the results of Herzer (2008).

After normalizing on $\ln Y_t$, we obtain the following equation (t-statistics are given in parentheses beneath the estimated coefficients):

$$\begin{aligned} \ln Y_t &= 6.970 + \underset{(11.236)}{0.723}\ln L_t + \underset{(21.389)}{0.353}\ln K_t + \underset{(15.863)}{0.030}\ln OFDI_t \\ LM(1) &= 22.24\,(0.14) \quad LM(3) = 13.93\,(0.60) \\ White &= 148.40\,(0.40) \quad JB = 3.39\,(0.91) \end{aligned} \tag{10}$$

Table 2. Tests for long-run exclusion and weak exogeneity

Variable		$\ln Y_t$	$\ln L_t$	$\ln K_t$	$\ln OFDI_t$
Long-run exclusion	$\chi^2(1)$ (p-values)	9.56 (0.002)	7.59 (0.006)	10.61 (0.001)	9.15 (0.002)
Weak exogeneity	$\chi^2(1)$ (p-values)	19.01 (0.00)	0.46 (0.497)	0.84 (0.359)	9.75 (0.002)

Note: The number of degrees of freedom υ in the $\chi^2(\upsilon)$ tests correspond to the number of zero restrictions.

where the numbers in parentheses behind the diagnostic test statistics are the corresponding p-values. All these test statistics indicate that the restricted model is statistically well-specified: the Lagrange multiplier (LM) tests for autocorrelation based on 1 and 3 lags, respectively, do not indicate any problems concerning autocorrelated residuals, the White test suggests that the model does not suffer from heteroscedasticity, and the Jarque Bera test (JB) cannot reject the hypothesis of normally distributed residuals. Moreover, all estimates are highly significant, which confirms the results of the long-run exclusion in Table 2.

The estimated factor output elasticities are consistent with the theoretical expectations. Admittedly, a labor elasticity of 0.723 is relatively high, given that the adjusted wage shares in German national income released by the European Commission are about 0.65. On the other hand, the estimated capital elasticity (0.353) is economically plausible, and the sum of the labor and capital coefficients is close to one, suggesting constant returns to scale (we will test for constant returns to scale in Section 5).

Turning to the estimated δ coefficient, we find that a 10% increase in the outward FDI stock is associated with an increase in GDP by 0.30%. From this it can be concluded that Germany benefits from outward FDI due to the increased productivity of the investing companies and associated productivity spillovers to local firms.

5. Econometric Results: TFP Equation Estimates

In order to check the robustness of the results obtained in the previous section, we estimate the relationship between total factor productivity and outward FDI given by equation (5). If there is no serious estimation problem, the estimate of equation (5) should produce approximately the same coefficient on outward FDI as equation (4), and thus a $\hat{\delta}$ value of roughly 0.030. However, for this prediction to hold there must be constant returns to scale in production, in turn implying that the output elasticities of labor and capital are equal to the factor shares in national income. Thus, the first step in this section is to test whether the assumption of constant returns to scale is justified. We then investigate the cointegration properties of total factor productivity and outward FDI and estimate the cointegration parameter δ (using a single equation approach). Finally, we test the direction of causality between the two variables.

We start by assessing the assumption of constant returns to scale. To this end, we use equation (10) from Section 4 and test three restrictions. The first restriction is that the estimated labor and capital coefficients sum to one, $\hat{a} + \hat{b} = 1$. If this restriction is not rejected, then production technology can be characterized by constant returns to scale. Regarding the other two restrictions, consider the following: as a consequence of constant returns to scale, the output elasticity with respect to labor and the output elasticity of capital must equal the share of labor in national income and the share of capital in national income, respectively. According to data from the European Commission, the labor share of Germany as a whole is about 0.65, which implies a capital share of 0.35.

Table 3. Wald Tests for constant returns to scale

Restriction	$\hat{a}+\hat{b}=1$	$\hat{a}=0.65$	$\hat{b}=0.35$
$\chi^2(1)$ (p-values)	0.881 (0.35)	0.251 (0.62)	0.954 (0.33)

Note: The number of degrees of freedom υ in the $\chi^2(\upsilon)$ tests correspond to the number of restrictions.

The second restriction to be tested is therefore $\hat{a}=0.65$, and the third restriction is $\hat{b}=0.35$. Table 3 presents Wald tests of these restrictions applied to equation (10). As can be seen, none of the restrictions are rejected, with p-values of 0.35, 0.62, and 0.33, respectively. Consequently, it is reasonable to assume constant returns to scale and to model total factor productivity accordingly as $\ln A_t = \ln Y_t - 0.65 \ln L_t - 0,35 \ln K_t$.

Now, we can proceed to test for cointegration and to estimate the cointegrating relationship between total factor productivity and outward FDI and given by equation (5). To this end, we make use of the Stock (1987) approach, regressing $\Delta \ln A_t$ on $\ln A_{t-1}$, $\ln OFDI_{t-1}$, the contemporaneous and lagged differences of $\ln OFDI_t$, on $\Delta \ln A_{t-1}$, and an intercept term. Successively eliminating the variables with the lowest t-values from the short-run part of the equation results in the following specification (t-statistics in parentheses beneath the estimated coefficients; numbers in parentheses after the values of the diagnostic test statistics are the corresponding p-values):

$$\begin{aligned}\Delta \ln A_t = \underset{(4.956)}{4.385} - \underset{(-4.159)}{0.732} \ln A_{t-1} + \underset{(4.161)}{0.021} \ln OFDI_{t-1} + \underset{(2.579)}{0.310} \Delta \ln A_{t-1} \\ \bar{R}^2 = 0.469 \quad SE = 0.009 \quad JB = 1.17\,(0.56) \\ LM(1) = 0.03\,(0.86) \qquad LM(3) = 0.28\,(0.84) \\ ARCH(1) = 0.00\,(0.99) \quad ARCH(4) = 0.60\,(0.67)\end{aligned} \tag{11}$$

None of the diagnostic test statistics is significant at conventional levels and, hence, the residuals appear to be normally distributed (JB), as well as free of autocorrelation (LM) and autoregressive conditional heteroscedasticity ($ARCH$). In addition, to exclude any bias, the stability of equation (11) is checked using the CUSUM of squares test and the plot of the recursive residuals. Neither of these tests, presented in Figure 1, indicates any instability of the estimated equation. Specifically, we conclude that no outliers are present in the model since the residuals in the right part of the figure persistently lie within the error bounds of −2 and +2 standard errors. Thus, valid statistical inferences can be drawn from the estimated coefficients.

A significant negative coefficient of the lagged dependent level variable indicates cointegration. Therefore, as the findings of Ericsson and MacKinnon (2002) suggest, this coefficient can be used to test for cointegration. The corresponding finite sample critical values can be calculated from the response surfaces in Ericsson

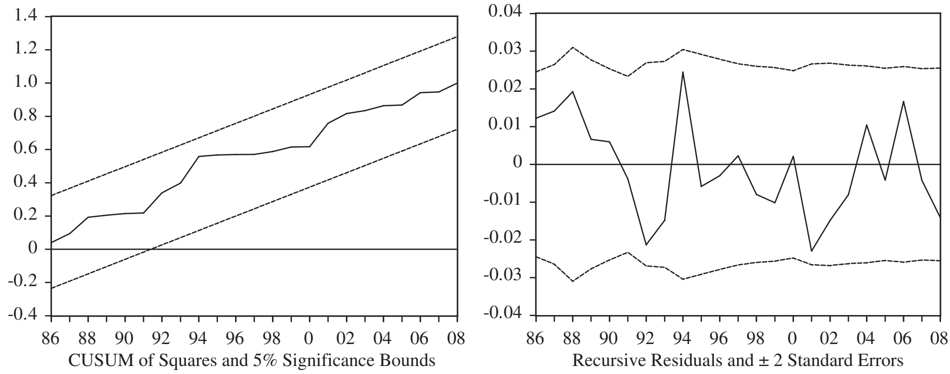

Figure 1. Stability analysis.

and MacKinnon (2002). Since the t-statistic of the coefficient (−4.159) exceeds in absolute value the finite sample critical value of −4.12 at the 1% level, the null of no cointegration can be rejected. Furthermore, the coefficient on $\ln OFDI_{t-1}$ is highly significant and positive, suggesting a positive role of outward FDI in total factor productivity in the long run. The short-run dynamics of outward investment, however, turned out to be insignificant, from which it can be concluded that outward investment does not affect productivity (and output) in the short run. Obviously, in the short run, there is a balance between the negative and positive effects of outward FDI, leading to insignificant short-run effects.

Normalizing on the coefficient of $\ln A_t$ yields the following long-run relationship:

$$\ln A_t = 0.029 \ln OFDI_t \tag{12}$$

Equation (12) implies that total factor productivity (and hence output) increases by 0.29% in response to a 10% increase in the outward FDI stock. Thus, the estimated δ value in equation (12) is almost identical to the estimated δ in equation (10). From this we conclude that our results are robust to different estimation techniques and model specifications.

Finally, we test for Granger causality between outward FDI and total factor productivity using a simple VAR model in levels. As shown by Toda and Phillips (1993), standard Wald tests for Granger causality based on levels VAR models are asymptotically chi-square distributed if the underlying variables are cointegrated with one cointegrating vector. Since only one cointegrating relationship exists between $\ln A_t$ and $\ln OFDI_t$ (because our model is bivariate), we test for causality by applying the standard Wald test for the significance of the lagged independent variables. Again, an impulse dummy for 1991 is included to account for an outlier. The test statistics are reported in Table 4. They show that causality runs in both directions – from outward FDI to total factor productivity and vice versa. Thus, this study also supports the macroeconomic implication of heterogeneous-firm models that outward FDI tends to increase when a country's aggregate productivity increases.

Table 4. Granger causality tests

	Dependent variable: $\ln A_t$	Dependent variable: $\ln OFD_t$	Conclusion
$\chi^2(1)$ (p-values)	21.07 (0.000)	10.27 (0.004)	$\ln OFDI_t \leftrightarrow \ln A_t$

Note: The VAR was estimated with one lag, as unanimously suggested by all standard lag selection criteria. $\ln OFD_t \leftrightarrow \ln A_t$ stands for 'causality runs from the outward FDI stock to total factor productivity and vice versa'. Numbers in parentheses behind the diagnostic test statistics are the corresponding p-values.

6. Conclusion

This paper adds to the literature on the home country effects of outward FDI. Previous studies focused primarily on analyzing the firm- and industry-level effects of outward FDI. This paper, in contrast, deals with the total effects of aggregate outward FDI on the economy as a whole. Specifically, the objective was to examine whether outward FDI affects domestic output via changes in total factor productivity. To this end, a production function approach was employed to estimate both the relationship between outward FDI and domestic output and the relationship between outward investment and total factor productivity. The empirical analysis was based upon German time series data from 1980–2008 and was performed using single-equation and system cointegration techniques. It was found that (i) there exists a long-run relationship between outward FDI and domestic output as well as between outward FDI and total factor productivity; (ii) in the long run, outward FDI has a positive impact on domestic output and total factor productivity, whereas the short-run productivity effects of outward FDI are statistically insignificant; and (iii) the causality between outward FDI and domestic output, and between outward FDI and total factor productivity runs in both directions: from outward FDI to domestic output and total factor productivity and vice versa.

Overall, the results of this study can be interpreted as evidence of productivity- and thus growth-enhancing effects of outward FDI, which is inconsistent with the simplistic notion that outward investment diverts resources away from domestic economic activity. Rather, the evidence presented here suggests that outward investing firms combine home production with foreign production to reduce costs and to increase their competitiveness both internationally and domestically. This benefits the entire domestic economy due to the increased productivity of the investing firms and the associated productivity spillovers to local firms.

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Appendix

Table A1. Unit root tests

Variables	Deterministic terms	ADF statistics	KPPS statistics
Levels			
$\ln Y_t$	c, t	−1.710 (−3.588)	0.150 (0.146)
$\ln L_t$	c, t	−1.688 (−3.581)	0.162 (0.146)
$\ln K_t$	c, t	−2.556 (−3.595)	0.155 (0.146)
$\ln TFP_t$	c, t	−3.387 (−3.588)	0.191 (0.146)
$\ln OFDI_t$	c, t	−1.634 (−3.581)	0.172 (0.146)
First differences			
$\Delta \ln Y_t$	c	−3.072 (−2.976)	0.171 (0.463)
$\Delta \ln L_t$	c	−4.626 (−2.976)	0.112 (0.463)
$\Delta \ln K_t$	c	−14.58 (−2.976)	0.455 (0.463)
$\Delta \ln TFP_t$	c	−9.011 (−2.976)	0.554 (0.463)
$\Delta \ln OFDI_t$	c	−4.626 (−2.976)	0.098 (0.463)

Note: c = constant; t = linear time trend. The relevant 5% critical values are in parentheses. The lag length for the ADF-test is chosen according to the Schwarz criterion, and the bandwidth choice for the KPSS-test follows the Newey-West criterion using a Bartlett kernel. The ADF test tests the null hypothesis of a unit root, while the KPSS test tests the null of stationarity.